3443

1

1.
Dr. Josef Stefan IV. S. 92.

Akustik.

M. Smoluchowski

10

Akustik

[illegible] Variat. [illegible]

[illegible]

[illegible]

[illegible]; [illegible] Var. [illegible] 30 [illegible] sec.; [illegible]

Var. [illegible]

[illegible] 30-40.000

[illegible]

Pythagoras [illegible]

[illegible] Taylor theoret.

[illegible] Mersenne [Harmonie 1635] experim. [illegible]

[illegible]

[illegible] [illegible] [illegible]

[illegible]

[illegible] Orgelpfeifen.

[illegible] theor. [illegible]

[illegible] Sirene [illegible] Cagniard de la Tour [illegible]

[illegible] Ak. [illegible]

[illegible]

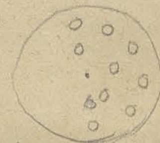
[illegible]

Dur Scala C D E F G A H C

[illegible] : Octave [illegible] $1 : \frac{1}{2}$ Pythag[illegible]

[illegible] $1 : 2$

[illegible] Sirene



2 [illegible]

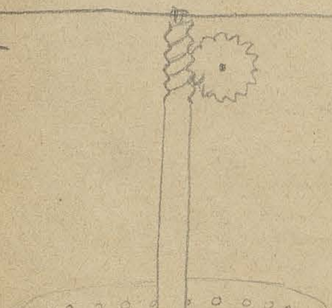
[illegible] Quint $\frac{2}{3} : 1$

$\frac{3}{2} : 1$

rel. [illegible] :

$1 \quad \frac{9}{8} \quad \frac{5}{4} \quad \frac{4}{3} \quad \frac{3}{2} \quad \frac{5}{3} \quad \frac{15}{8} \quad 2$

4/5



[illegible] Monochord [illegible]

[illegible]

$$\sigma = a \sin 2n\pi t$$

$$\sigma = 0 \qquad 2n\pi t = \pi,\ 2\pi,\ 3\pi$$

$$t = \frac{1}{2n},\ 2\frac{1}{2n},\ 3\frac{1}{2n}, \ldots$$

$$\frac{d\sigma}{dt} = 2n\pi a \cos 2n\pi t$$

$\frac{d\sigma}{dt}$ + [illegible]

$$\frac{d\sigma}{dt} = 2n\pi a\,[-1, +1, -1, +1, \ldots]$$

[illegible]

$t_1 = \frac{1}{n}$ = [illegible] [[illegible] $\frac{1}{2n}$ [illegible] = [illegible]]

[illegible]

[illegible]:

$$\sigma' = a' \sin 2n'\pi t$$

$\sigma + \sigma'$ = [illegible] $\qquad n' > n$

$$n' = n + x$$

$$\sigma + \sigma' = a \sin 2n\pi t + a' \sin(2n\pi t + 2x\pi t)$$

$$= a \sin 2n\pi t + a' \sin 2n\pi t \cos 2x\pi t + a' \cos 2n\pi t \sin 2x\pi t$$

$$= (a + a' \cos 2x\pi t) \sin 2n\pi t + a' \sin 2x\pi t \cos 2n\pi t$$

$a + a' \cos 2x\pi t = A \cos\varphi$

$a' \sin 2x\pi t = A \sin\varphi$

$\sigma + \sigma' = A \sin(2n\pi t + \varphi)$

$a^2 + 2aa' \cos 2x\pi t + a'^2 = A^2$

(Ordin.) [illegible] 2 per. fc.

[illegible]

[illegible]

[illegible] $A = 0$ [illegible] $a^2 + a'^2 + \dots = 0$

$a = a'$ $\cos 2x\pi t = -1$

[illegible] $A =$ [illegible]

Maxim. [illegible] $\cos 2x\pi t = +1$

$2x\pi t = 0, 2\pi, 4\pi, \dots$

$t = 0, \frac{1}{x}, 2\frac{1}{x}, 3\frac{1}{x}, \dots$

[illegible]

[illegible]

5/5 Monochorde [illegible] horiz. [illegible]

vertik. [illegible]

[illegible]

[illegible] Mersenne (1635)

Sauveur (1701) [illegible]

[illegible]

[illegible] Octave.

[illegible] $\frac{1}{2}$, $\frac{1}{3}$ etc. [illegible]

[illegible] 16tel [illegible]

[illegible] [[illegible]]. [illegible] 2 [illegible]

[illegible] 2te [illegible]

[illegible] Octave [illegible].

[illegible]

[illegible] $\frac{1}{3}$ [illegible] $\frac{1}{3}$ [illegible] etc.

[illegible] $\frac{1}{4}$ [illegible] 3/4 [illegible] $\frac{1}{4}$ [illegible]

[illegible] Sauveur.

[illegible] : Octave etc. [illegible]

[illegible]

Obertöne

Grundton	Octave	Quint d. Octave,	2te Octave
1. [illegible]	2 [illegible]	3. [illegible]	

[illegible]

[illegible]

[illegible]

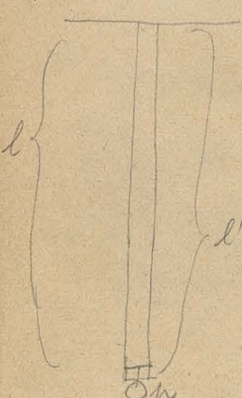
[illegible]

[illegible]

[illegible]

6/5 [illegible]

[illegible] Elastic.



[illegible]

[illegible] Newtons [illegible] Hooke

[illegible] $(l'-l) = \eta \frac{P}{q} l$

$$P = \frac{q(l'-l)}{\eta l} = \mathfrak{E} q \frac{l'-l}{l}$$

$\frac{l'-l}{l}$ = relat. [illegible] $\frac{1}{\eta} = \mathfrak{E}$

$\mathfrak{E}$ = Elasticitätscoëfficient

$q = 1$ | $l'-l = l$ | [illegible]

$P = \mathfrak{E}$ = $\mathfrak{E}$, [illegible] = 1.

zB. [illegible] 1 mm² [illegible] $\mathfrak{E}$ = 10 000 kg

1 cm² $\mathfrak{E}$ = 10.00 000 kg

[illegible]

[illegible]

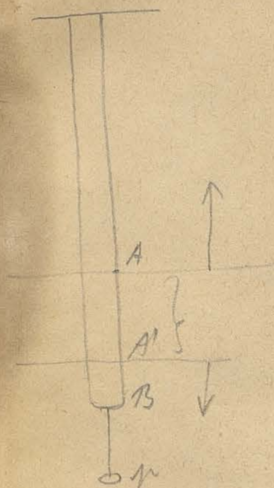
[illegible]

[illegible] elast. [illegible] [[illegible]].

[illegible] elast. [illegible] zB. [illegible] Torsion

[illegible] Wilh. Weber [illegible] Torsions [illegible] const.

[illegible]



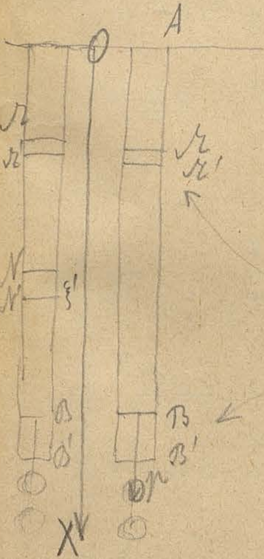
[illegible] Elast. [illegible]

[illegible]

[illegible] $= pg.$

[illegible]

$1 : p = pg.$



$AB = l$

$A\Lambda = x$

$\Lambda\Lambda' = \xi$

$BB' = \lambda$

$P = \frac{Q g \lambda}{l}$

$P = \frac{Q g \xi}{x}$

$\frac{Q g \lambda}{l} = \frac{Q g \xi}{x}$

$\frac{\lambda}{l} = \frac{\xi}{x}$

[illegible] N:

$\frac{\lambda}{l} = \frac{\xi'}{x'}$

$\frac{\lambda}{l} = \frac{\xi}{x} = \frac{\xi'}{x'} = \frac{\xi' - \xi}{x' - x}$

[illegible]

$\xi = f(x)$

$\frac{\lambda}{l} = \frac{\xi' - \xi}{x' - x} = \frac{d\xi}{dx}$

$P = \mathfrak{E} q \frac{d\xi}{dx}$ [illegible]

203.



$s = sp.$ [illegible]

[illegible]

$q(l-x)s = \mathfrak{E} q \frac{d\xi}{dx}$ [illegible]

$\frac{s}{\mathfrak{E}}(l-x) = \frac{d\xi}{dx}$

$\xi = \frac{s}{\mathfrak{E}}\left[lx - \frac{x^2}{2}\right] + C$

$x=0 \quad 0 = 0 + C$

$\xi = \frac{s}{\mathfrak{E}}\left[lx - \frac{x^2}{2}\right]$

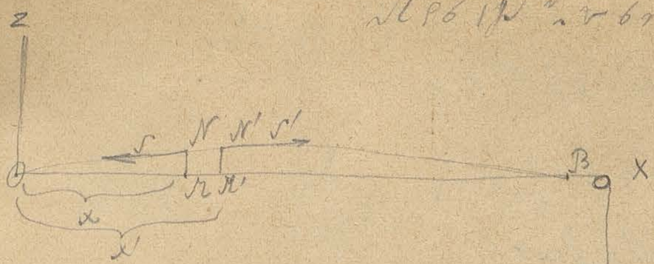
$\lambda = \frac{s}{\mathfrak{E}} \frac{l^2}{2}$ $\quad sl = p =$ [illegible]

$= \frac{pl}{2\mathfrak{E}}$

[illegible]

$^{10}/_5$

[illegible] B [illegible]



$x' - x = \lambda$

$\xi =$ [illegible] Absc. [illegible] $\qquad \xi' =$ [illegible] Absc. [illegible] M'

$\zeta =$ Z Coord. [illegible] $N \qquad \zeta'$ — — N'

[illegible]

$\xi = \varphi(x) \qquad \xi' = \varphi(x')$

$= \varphi(x+\lambda) = \varphi(x) + \lambda \varphi'(x)$

$\xi' = \xi + \lambda \frac{d\xi}{dx}$

[illegible] $\zeta = \psi(x) \qquad \zeta' = \psi(x+\lambda)$

$\zeta' = \zeta + \lambda \frac{d\zeta}{dx}$ [illegible] MM' — NN'

[illegible]

[illegible] N' [illegible] S'



$X = -S\cos\alpha \qquad X' = S'\cos\alpha'$

$Z = -S\sin\alpha \qquad Z' = S'\sin\alpha'$

$$\left\{\begin{aligned} m\frac{d^2\zeta}{dt^2} &= -S\sin\alpha + S'\sin\alpha' \\ m\frac{d^2(x+\xi)}{dt^2} &= -S\cos\alpha + S'\cos\alpha' = m\frac{d^2\xi}{dt^2} \end{aligned}\right\}$$ [illegible]

[illegible] $MM' = NN' = \mu\, MM' = \mu\lambda$

[illegible] $f(x)$ [illegible]

$$S \sin\alpha = f(x)$$

$$S' \sin\alpha' = f(x+\lambda)$$

$$= f(x) + \lambda f'(x) = S\sin\alpha + \lambda \frac{d(S\sin\alpha)}{dx}$$

$$\mu\lambda \frac{d^2\xi}{dt^2} = \lambda \frac{d(S\sin\alpha)}{dx}$$ [illegible]

$$\mu \frac{d^2\xi}{dt^2} = \frac{d}{dx}(S\sin\alpha)$$

$$\mu \frac{d^2\xi}{dt^2} = \frac{d}{dx}(S\cos\alpha)$$

$$S = P + \mathcal{E} q \frac{(NN' - MM')}{r r'}$$

$$NN'^2 = (x' + \xi' - x - \xi)^2 + (\xi' - \xi)^2$$

$$= \left(\lambda + \lambda \frac{d\xi}{dx}\right)^2 + \lambda^2 \left(\frac{d\xi}{dx}\right)^2$$

$$= \lambda^2 \left[1 + 2\frac{d\xi}{dx} + \left(\frac{d\xi}{dx}\right)^2\right] + \lambda^2 \left(\frac{d\xi}{dx}\right)^2$$

[illegible]

$$S = P + \mathcal{E} q \frac{\lambda \sqrt{1 + 2\frac{d\xi}{dx} + \left(\frac{d\xi}{dx}\right)^2 + \left(\frac{d\xi}{dx}\right)^2} - \lambda}{\lambda}$$

[illegible]

$\frac{d\xi}{dx}$ [illegible] $\frac{d\xi}{dx}$

$$S = P + \mathcal{E}q \frac{\sqrt{1+2\frac{d\xi}{dx}} - 1}{1} = P + \mathcal{E}q \frac{d\xi}{dx}$$

$$\sin\alpha = \frac{tg\alpha}{\sqrt{1+tg^2\alpha}} = \frac{\frac{d\xi}{dx}}{\sqrt{1+\left(\frac{d\xi}{dx}\right)^2}} \mp \frac{d\xi}{dx}$$

[illegible] α [illegible] tg.

[illegible] $\cos\alpha = 1$

$$\mu \frac{d^2\xi}{dt^2} = \frac{d}{dx}\left[S\cos\alpha\right] = \frac{d}{dx}\left[P + \mathcal{E}q \frac{d\xi}{dx}\right]$$

$$= \mathcal{E}q \frac{d^2\xi}{dx^2}$$ [illegible] longitud. [illegible]

[illegible]

$\mu = \rho q . 1$

$$\rho \frac{d^2\xi}{dt^2} = \mathcal{E} \frac{d^2\xi}{dx^2}$$ [illegible] longit. [illegible]

[illegible]

$$\mu \frac{d^2\xi}{dt^2} = \frac{d}{dx}\left[\left(P + \mathcal{E}q \frac{d\xi}{dx}\right)\frac{d\xi}{dx}\right]$$

$$= \frac{d}{dx}\left[P \frac{d\xi}{dx} + \underbrace{\mathcal{E}q \frac{d\xi}{dx}\frac{d\xi}{dx}}\right]$$

[illegible]

$$\mu \frac{d^2\xi}{dt^2} = P \frac{d}{dx}\left(\frac{d\xi}{dx}\right)$$

$$\mu \frac{d^2\xi}{dt^2} = P \frac{d^2\xi}{dx^2}$$ [illegible] transv. [illegible]

[illegible]

12/5

$$m\frac{d^2\xi}{dt^2} = \frac{P}{\mu}\frac{d^2\xi}{dx^2} \qquad \frac{P}{\mu} = a^2$$

$$\frac{d^2\xi}{dt^2} = a^2\frac{d^2\xi}{dx^2}$$ [illegible]

$$\xi = f(x,t) = X.T$$ [illegible] $f(x)$ [illegible] $f(t)$

$$X\frac{d^2T}{dt^2} = a^2\, T\frac{d^2X}{dx^2}$$

$$\frac{\frac{d^2T}{dt^2}}{T} = a^2\frac{\frac{d^2X}{dx^2}}{X} = c$$ [illegible]

[illegible] $$\frac{d^2T}{dt^2} = cT \qquad \frac{d^2X}{dx^2} = \frac{c}{a^2}X$$

$$T = Ae^{\sqrt{c}\,t} + Be^{-\sqrt{c}\,t}$$

[illegible] per [illegible]

[illegible] per. [illegible]

$$\frac{d^2T}{dt^2} = -\alpha^2 T$$

$$T = A\cos\alpha t + B\sin\alpha t$$

$$\frac{d^2X}{dx^2} = -\frac{\alpha^2}{a^2}X$$

$$X = C\cos\frac{\alpha x}{a} + D\sin\frac{\alpha x}{a}$$

$$\xi = \left[C\cos\frac{\alpha x}{a} + D\sin\frac{\alpha x}{a}\right]\left[A\cos\alpha t + B\sin\alpha t\right]$$

[illegible] per. [illegible] ; [illegible] Ampl. [illegible]

[illegible]

[illegible] $x=0 \quad \xi=0$

$x=l \quad \xi=0$



$$\xi = 0 = C \cdot T \qquad C=0$$

$$\xi = D\sin\frac{\alpha x}{a} \cdot T$$

$x=l$

$$\xi = 0 = D\sin\frac{\alpha l}{a} \cdot T \qquad D\sin\frac{\alpha l}{a} = 0$$

[illegible] $=0$ [illegible] $D=0$ [illegible] ; [illegible] $\sin\frac{\alpha l}{a} = 0$

α [illegible] Const. α :

$$\frac{\alpha l}{a} = 0,\ \pi,\ 2\pi,\ 3\pi \ldots$$

$$\frac{\alpha l}{a} = \pi \qquad \alpha = \frac{a\pi}{l}$$

$$\xi = D\sin\frac{\pi x}{l}\left[A\cos\frac{a\pi t}{l} + B\sin\frac{a\pi t}{l}\right]$$

$$DA = F \quad DB = G$$

$$\xi = \sin\frac{\pi x}{l}\left[F\cos\frac{\pi a t}{l} + G\sin\frac{\pi a t}{l}\right]$$

$\frac{\pi a t}{l} = 2\pi$ [illegible]

$\tau = \frac{2l}{a}$ = [illegible]

[illegible] $= \frac{1}{\tau} = n = \frac{a}{2l} = \frac{1}{2l}\sqrt{\frac{P}{\mu}}$

[illegible]:

$\alpha l = 2\pi,\ 3\pi, \ldots\ h\pi$

$\alpha = \frac{a h \pi}{l}$

$\xi' = \sin\frac{h\pi x}{l}\left[F\cos\frac{h\pi a t}{l} + G\sin\frac{h\pi a t}{l}\right]$

$\frac{h\pi a \tau'}{l} = 2\pi$

$\tau' = \frac{2l}{ha}$ $\quad n' = \frac{1}{\tau'} = \frac{h}{2l}a = \frac{h}{2l}\sqrt{\frac{P}{\mu}}$

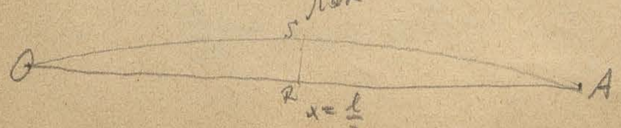
[illegible]

$n =$ [illegible]

[illegible] 2, 3, 4 — [illegible]

$h = 1$

[illegible] $\sin\frac{\pi x}{l}$ [illegible]



$R\xi = \sin F \cos\frac{n a t}{l} + \mathfrak{G} \sin\frac{n a t}{l}$

[illegible] Curve [illegible] sin.-lin.

$\underline{n=2}$

$x = \frac{l}{2} \quad \xi = 0$



[illegible]

$\underline{n=3}$

$\left. \begin{array}{l} x = \frac{l}{3} \\ x = \frac{2l}{3} \end{array} \right\} \xi = 0$



$\underline{n=4}$



etc.

[illegible] Σ [illegible]

[illegible] Σ [illegible]

$$\xi = \sin\frac{\pi x}{l}\left[F_1 \cos\frac{\pi a t}{l} + \mathfrak{G}_1 \sin\frac{\pi a t}{l}\right] +$$

$$+ \sin\frac{2\pi x}{l}\left[F_2 \cos\frac{2\pi a t}{l} + \mathfrak{G}_2 \sin\frac{2\pi a t}{l}\right] +$$

$$+ \sin\frac{3\pi x}{l}\left[F_3 - - \qquad \right] +$$

$$+ - - - - -$$

[illegible] F [illegible] $\mathfrak{G}$ [illegible]

[illegible] Const. [illegible]

[illegible]

[illegible] $t=0$.

12/5 $\xi = \sin\frac{\pi x}{l}\left[F_1 \cos\frac{\pi a t}{l} + G_1 \sin\frac{\pi a t}{l}\right] +$

$+ \sin\frac{2\pi x}{l}\left[F_2 \cos\frac{2\pi a t}{l} + G_2 \sin\frac{2\pi a t}{l}\right] +$

$+ \cdots$

$$\frac{d\xi}{dt} = -\frac{\pi a}{l}\sin\frac{\pi x}{l}\left[F_1 \sin\frac{\pi a t}{l} - G_1 \cos\frac{\pi a t}{l}\right] +$$

$$-\frac{2\pi a}{l}\sin\frac{2\pi x}{l}\left[F_2 \sin\frac{2\pi a t}{l} - G_2 \cos\frac{2\pi a t}{l}\right] +$$

$- \cdots$

$t=0$ | $\xi = \varphi(x) \qquad \frac{d\xi}{dt} = \psi(x)$

$$\varphi(x) = F_1 \sin\frac{\pi x}{l} + F_2 \sin\frac{2\pi x}{l} + F_3 \cdots$$

$$\psi(x) = \frac{\pi a}{l} G_1 \sin\frac{\pi x}{l} + \frac{2\pi a}{l} G_2 \sin\frac{2\pi x}{l} + \cdots$$

[illegible] ∞ [illegible] repr. [illegible]

[illegible]

[illegible] Ord. [illegible]

Lagranges [illegible] Const. [illegible]

[illegible] ∞ [illegible].

[illegible] Lagr. [illegible] Fourier [illegible]

$\varphi(x)$ [illegible] $f(x)$ [illegible]

[illegible] $\left.\begin{matrix} x=0 \\ x=l \end{matrix}\right\}$ $=0$ [illegible]

[illegible]

$$J = \int_0^l \sin\frac{h\pi x}{l} \cdot \sin\frac{k\pi x}{l}\, dx = 0$$ [illegible]

h, k [illegible]

BW:

$$= \frac{1}{2}\int_0^l dx \left[\cos\frac{(h-k)\pi x}{l} - \cos\frac{(h+k)\pi x}{l}\right]$$

$$= \frac{1}{2}\frac{l}{(h-k)\pi}\sin\frac{(h-k)\pi x}{l}\Big|_0^l - \frac{1}{2}\frac{l}{(h+k)\pi}\sin\frac{(h+k)\pi x}{l}\Big|_0^l = 0$$

$\neq$ [illegible] $h = k$ [illegible] $\frac{l}{0}$ [illegible]:

$$J' = \int_0^l \sin^2\frac{h\pi x}{l}\, dx = \frac{1}{2}\int_0^l 1 - \cos\frac{2h\pi x}{l}\, dx$$

$$= \frac{l}{2}$$

[illegible] F_1 [illegible]:

$$\int_0^l \sin\frac{\pi x}{l}\,\varphi(x)\, dx = \int_0^l F_1 \sin^2\frac{\pi x}{l}\,dx + \int_0^l F_2 \sin\frac{\pi x}{l}\sin\frac{2\pi x}{l}\,dx + \dots$$

$$= F_1 \frac{l}{2}$$

$$\int_0^l \sin\frac{2\pi x}{l}\,\varphi(x)\, dx = F_2\frac{l}{2}$$

etc. [illegible]

$$F_k = \frac{2}{l}\int_0^l \varphi(x)\sin\frac{k\pi x}{l}\,dx$$

$$G_k = \frac{2}{k\pi a}\int_0^l \psi(x)\sin\frac{k\pi x}{l}\,dx$$

[illegible]. [illegible]:



[illegible] $=0$ $\psi(x)=0$

[illegible] $G_k=0$

$Om = x$ $mm' = \xi$ $BB' = c$ $OB = \lambda$

$\xi : c = x : \lambda$

$\xi = \frac{cx}{\lambda}$ [illegible]

$\varphi(x) = \frac{cx}{\lambda}$ [illegible] $x=0$ [illegible] $x=\lambda$

$\mu\mu' = \xi$ $\xi : c = A\mu : AB$

$= l-x : l-\lambda$

$\varphi(x) = \xi = \frac{c(l-x)}{l-\lambda}$ [illegible] $x=\lambda$ [illegible] $x=l$

$$F_k = \frac{2}{l}\int_0^\lambda \frac{cx}{\lambda}\sin\frac{k\pi x}{l}\,dx + \frac{2}{l}\int_\lambda^l \frac{c(l-x)}{l-\lambda}\sin\frac{k\pi x}{l}\,dx$$

$$\frac{l F_h^*}{2c} = \frac{1}{\lambda}\left[-\frac{x l}{h\pi}\cos\frac{h\pi x}{l}\Big|_0^\lambda + \frac{l}{h\pi}\int_0^\lambda \cos\frac{h\pi x}{l}\,dx\right]$$

$$+\frac{1}{l-\lambda}\left[-\frac{(l-x)\, l}{h\pi}\cos\frac{h\pi x}{l}\Big|_\lambda^l - \frac{l}{h\pi}\int_\lambda^l \cos\frac{h\pi x}{l}\,dx\right]$$

$$= \frac{1}{\lambda}\left[-\frac{\lambda l}{h\pi}\cos\frac{h\pi\lambda}{l} + \frac{l^2}{h^2\pi^2}\sin\frac{h\pi\lambda}{l}\right]$$

$$+\frac{1}{l-\lambda}\left[+\frac{(l-\lambda)\, l}{h\pi}\cos\frac{h\pi\lambda}{l} + \frac{l^2}{h^2\pi^2}\sin\frac{h\pi\lambda}{l}\right]$$

$$= \frac{l^2}{h^2\pi^2}\left(\frac{1}{\lambda}+\frac{1}{l-\lambda}\right)\sin\frac{h\pi\lambda}{l}$$

$$F_h = \frac{2c\, l^2}{h^2\pi^2\lambda(l-\lambda)}\sin\frac{h\pi\lambda}{l}$$

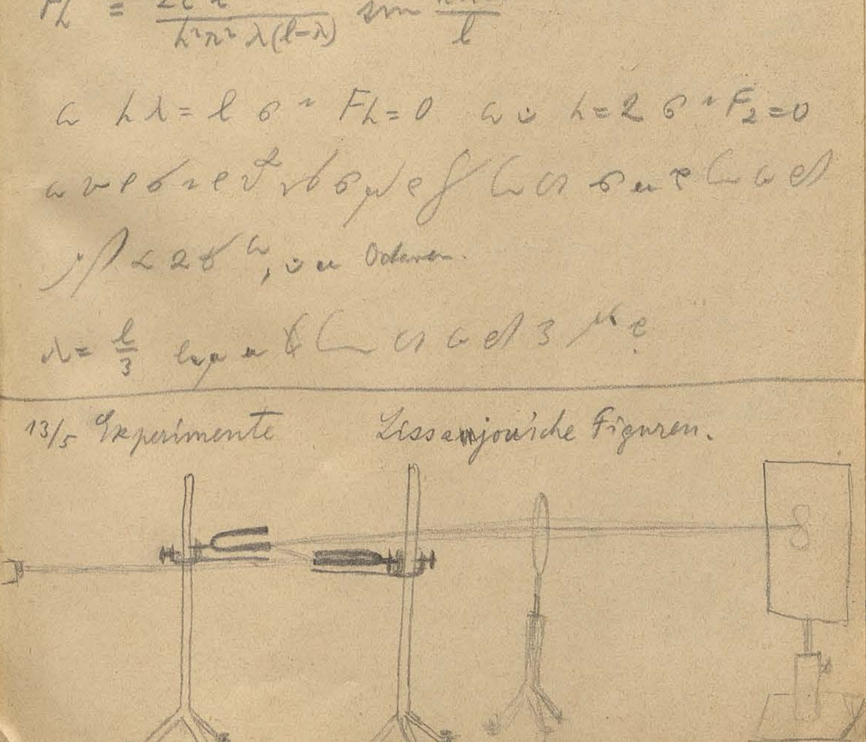
[illegible] $h\lambda = l$ [illegible] $F_h = 0$ [illegible] $h = 2$ [illegible] $F_2 = 0$

[illegible]

[illegible] Oktaven.

$\lambda = \frac{l}{3}$ [illegible] 3 [illegible]

13/5 Experimente Lissajou'sche Figuren.



[illegible]

$x = a \sin \alpha t \qquad y = b \sin \alpha t$

$\frac{x}{y} = \frac{a}{b}$ [illegible] $\frac{b}{a}$

$x = a \sin \alpha t \qquad y = b \cos \alpha t$

$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ Ellipse

[illegible]

$x = \frac{\sin}{\cos} \alpha t \qquad y = \frac{\sin}{\cos} \alpha t$

[illegible]

[illegible]

$t = 0 \qquad x = 0 \qquad z = 0$

$\alpha t = \pi \qquad \alpha t \neq \pi$ [illegible]

[illegible] Ell. [illegible] Ell. [illegible]

[illegible]

[illegible]

[illegible] [[illegible]]

[illegible]

$\alpha t - \alpha' t = 2\pi$

$\alpha = 2n\pi$

$\alpha' = 2\pi(n+\nu)$

$2\pi\nu t = 2\pi$

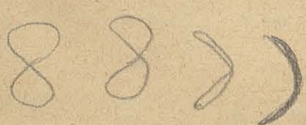
$\nu = \frac{1}{t}$ $t =$ [illegible]

[illegible]

[illegible] 1° [illegible]

[illegible]

[illegible] Octave



$x = a\cos 2\alpha t$
$y = b\sin\alpha t$

$x = a\cos^2\alpha t - a\sin^2\alpha t$

$x = a - 2a\sin^2\alpha t$

$x = a - \frac{2a}{b}y^2$

$(a-x)\frac{b}{2a} = y^2$ [illegible] Parabel

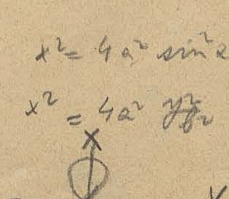
$x = a\sin 2\alpha t$
$y = b\sin\alpha t$

$x = 2a\sin\alpha t\cos\alpha t$

$x^2 = 4a^2\sin^2\alpha t\,[1-\sin^2\alpha t]$

$x^2 = 4a^2\frac{y^2}{b^2}\left[1-\frac{y^2}{b^2}\right]$ C. 4 [illegible]

[illegible] 4 y [illegible]



Gr[illegible] $x = \sin 3\alpha t$

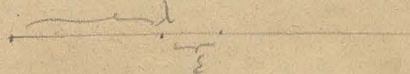
$y = \sin(\alpha t + \theta)$

17/5 [illegible]

[illegible] $= 0$ [illegible] ≥ 0 [illegible]

[illegible] $t = 0$ [illegible]

[illegible]



$\xi = 0 \quad \frac{d\xi}{dt} = c$ [illegible] $x = \lambda$ [illegible] $x = \lambda + \varepsilon$

$$\xi = \sin\frac{\pi x}{l}\left[F_1 \cos\frac{\pi a t}{l} + G_1 \sin\frac{\pi a t}{l}\right] + \text{———}$$

$$\frac{d\xi}{dt} = -\frac{\pi a}{l}\sin\frac{\pi x}{l}\left[F_1 \sin\frac{\pi a t}{l} + G_1 \cos\frac{\pi a t}{l}\right] + \text{———}$$

$$0 = F_1 \sin\frac{\pi x}{l} + F_2 \sin\frac{2\pi x}{l} + \text{———}$$

$$F_1 = F_2 = \text{———} \quad 0$$

$$\int_\lambda^{\lambda+\varepsilon} \psi(x)\,dx \sin\frac{n\pi x}{l} = \frac{n\pi a}{l} G_n \frac{l}{2}$$

$$-\frac{lc}{n\pi}\cos\frac{n\pi x}{l}\Big|_\lambda^{\lambda+\varepsilon} =$$

$$G_n = \frac{2lc}{n^2\pi^2 a}\left[\cos\frac{n\pi\lambda}{l} - \cos\frac{n\pi(\lambda+\varepsilon)}{l}\right]$$

$$g_n = \frac{4lc}{n^2\pi^2 a} \sin\frac{n\pi(\lambda+\frac{\varepsilon}{2})}{l} \sin\frac{n\pi\frac{\varepsilon}{2}}{l}$$

[illegible]

$$= \frac{2c\varepsilon}{n\pi a} \sin\left(n\pi\left(\frac{\lambda+\frac{\varepsilon}{2}}{l}\right)\right)$$

[illegible]

$$\frac{n\pi(\lambda+\frac{\varepsilon}{2})}{l} = \pi \quad [illegible] \; g=0$$

$$\lambda+\frac{\varepsilon}{2} = \frac{l}{n}$$ [illegible]

[illegible] Octave

[illegible] 3 [illegible] $\frac{1}{3}$ [illegible] $\frac{2}{3}$ [illegible]

[illegible]

Longitudinale [illegible]

$$\frac{d^2\xi}{dt^2} = \frac{E}{\rho}\frac{d^2\xi}{dx^2}$$ [illegible]

[illegible] transv. [illegible]

[illegible] long. [illegible] transv. [illegible]



$$S = -Eq\frac{d\xi}{dx}$$

$$= -f(x)$$

$S' = f(x+\varepsilon)$

$$\rho q \varepsilon \frac{d^2\xi}{dt^2} = S' - S = f(x+\varepsilon) - f(x)$$

$$\rho q \frac{d^2\xi}{dt^2} = \frac{f(x+\varepsilon) - f(x)}{\varepsilon} = \frac{df(x)}{dx}$$

$$\rho q \frac{d^2\xi}{dt^2} = \frac{d}{dx}\left(\mathfrak{E} q \frac{d\xi}{dx}\right)$$ [illegible]

[illegible]

$$= \mathfrak{E} q \frac{d^2\xi}{dx^2}$$ [illegible]

$$\frac{d^2\xi}{dt^2} = \frac{\mathfrak{E}}{\rho} \frac{d^2\xi}{dx^2}$$

[illegible]

[illegible]

[illegible]

[illegible] $\xi = 0$. [illegible]?



$$\rho q \varepsilon \frac{d^2\xi}{dt^2} = -\mathfrak{E} q \frac{d\xi}{dx}$$

[illegible] S

$$\frac{d^2\xi}{dt^2} = -\frac{\mathfrak{E}}{\rho\varepsilon} \frac{d\xi}{dx}$$ [illegible] $\frac{d^2\xi}{dt^2} = \infty$ [illegible]

[illegible] $\frac{d\xi}{dx} = 0$ [illegible] $S = 0$.

$$\frac{\mathfrak{E}}{\rho} = a^2$$

$$\xi = \sin\alpha t\,[A\cos\beta x + B\sin\beta x]$$

$$\alpha^2 = a^2\beta^2$$

$$+\cos\alpha t\,[C\cos\beta x + D\sin\beta x]$$ 8 part. ∫

[illegible]

$x=0|$ $x=l|$ $\frac{d\xi}{dx}=0$

$$\frac{d\xi}{dx} = \sin\alpha t\,[-A\beta\sin\beta x + B\beta\cos\beta x] +$$
$$+\cos\alpha t\,[-C\beta\sin\beta x + D\beta\cos\beta x]$$

$x=0$

$$\frac{d\xi}{dx} = \sin\alpha t\, B\beta + \cos\alpha t\, D\beta = 0$$

$B=0$ $D=0$ [illegible]

$$\xi = \cos\beta x\,[A\sin\alpha t + C\cos\alpha t]$$

$$\frac{d\xi}{dx} = -\beta\sin\beta x\,[A\sin\alpha t + C\cos\alpha t]$$

$x=0$ $=0$

$\sin\beta l = 0$

$\beta l = \pi, 2\pi, 3\pi$ ———

[illegible]: $\alpha = a\beta$

$= \frac{2\pi}{\tau} = 2n\pi$ $2n\pi = a\beta$

$= a\left[\frac{\pi}{l}, \frac{2\pi}{l} \cdots\right]$

$n = \frac{a}{2l}[1, 2, 3 \cdots\cdots$

$n = \sqrt{\frac{q}{\rho}} \, \frac{1}{2l} \left[1, \; 2, \; \ldots \right]$

[illegible], Octave etc.

$\xi = \cos \frac{\pi x}{l} \left[A_1 \sin \alpha t + C_1 \cos \alpha t \right]$

$\beta = \frac{2\pi}{l}$

$\xi = \cos \frac{2\pi x}{l} \left[A_2 \sin \ldots \right]$

[illegible] Σ

$\xi = \ldots$

[illegible]

[illegible] – [illegible]

[illegible] etc.

[illegible] Ukarzsormen [illegible].

Octave $\quad x = \underbrace{\frac{l}{4}}, \; \underbrace{\frac{3l}{4}, \; \frac{5l}{4}} \ldots$

Abscissen [illegible] $\quad$ [illegible]

Octave:



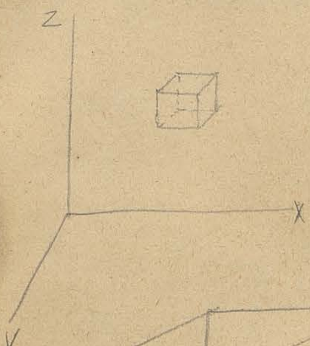
[illegible] $3, 2^e$ [illegible]?

18/5 [illegible] Hydrostatik [illegible] Hydrodynamik

[illegible]

[illegible] = ~~[illegible]~~ $\rho\alpha\beta\gamma$

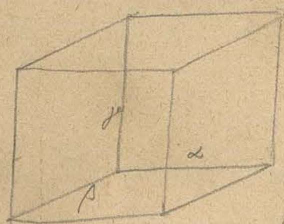
[illegible]



I. [illegible]

[illegible]

[illegible]



~~[illegible]~~ $\rho\alpha\beta\gamma X =$ [illegible] $\parallel X$ [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] $= p$.

$\beta\gamma \cdot p =$ [illegible] $\} \parallel X$

$-\beta\gamma\, p'$ ~~[illegible]~~ " " [illegible]

$$\rho\alpha\beta\gamma X + \beta\gamma p - \beta\gamma p' = 0$$ [illegible] X [illegible]

$p = f(x, y, z)$
$p' = f(x+\alpha, y, z)$

$$\rho X + \frac{p-p'}{\alpha} = 0$$

$$\rho X - \frac{\partial p}{\partial x} = 0$$ [illegible] $\parallel X$ [illegible]

[illegible]

$$\left.\begin{aligned} \rho X - \frac{\partial p}{\partial x} &= 0 \\ \rho Y - \frac{\partial p}{\partial y} &= 0 \\ \rho Z - \frac{\partial p}{\partial z} &= 0 \end{aligned}\right\}$$ [illegible] Hydrostatik

X, Y, Z [illegible]

[illegible] reduc. [illegible]

$$\rho\,\alpha\beta\gamma\,X - \alpha\beta\gamma\,\frac{dp}{dx} = \rho\,\alpha\beta\gamma\,F_x$$

$F_x =$ [illegible] $\parallel X$ [illegible]

[illegible] $\frac{d^2x}{dt^2}$ [illegible] t; [illegible]

[illegible] $\frac{dp}{dx}$ [illegible]

[illegible] Euler'sche [illegible] Par. [illegible]

[illegible] geom. Par. [illegible]

[illegible] Par.

[illegible] Par. [illegible] u, v, w [illegible] t [illegible] τ

[illegible] Par. [illegible] u',

$$\frac{u' - u}{\tau} = \text{[illegible]} = F_x$$

$$u = \varphi(x, y, z, t)$$

$$u' = \varphi(x + u\tau,\ y + v\tau,\ z + w\tau,\ t + \tau)$$ [illegible] Taylor

$$= u + \frac{du}{dx}\,u\tau + \frac{du}{dy}\,v\tau + \frac{du}{dz}\,w\tau + \frac{du}{dt}\,\tau$$

$$\lim \frac{u'-u}{\tau} = F_x = \frac{du}{dt} + u\frac{du}{dx} + v\frac{du}{dy} + w\frac{du}{dz}$$

$$\rho X - \frac{dp}{dx} = \rho\left[\frac{du}{dt} + u\frac{du}{dx} + v\frac{du}{dy} + w\frac{du}{dz}\right]$$
ρY — —
ρZ — —
} [illegible] Hydrodyn.

[illegible] xyz [illegible]

[illegible] u, v, w [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] Continuitätsg[illegible].

[illegible] $\rho u \tau$: $= \beta\gamma \rho u \tau$

[illegible] — — $\beta\gamma (\rho u)' \tau$

$\rho u = \psi(x, y, z, t)$

$(\rho u)' = \psi(x+\alpha, y, z, t)$

$(\rho u)' = \psi + \frac{\partial \psi}{\partial x}\alpha = \rho u + \frac{d(\rho u)}{dx}\alpha$

$\beta\gamma\rho u\tau - \beta\gamma(\rho u)'\tau =$ [illegible] $= \beta\gamma\tau\left(\rho u - \rho u + \frac{d(\rho u)}{dx}\alpha\right)$

$$= -\alpha\beta\gamma\tau \frac{d(\rho u)}{dx}$$

[illegible] $\parallel X$: $-\alpha\beta\gamma\tau \dfrac{d(\rho u)}{dx}$

" " " Y: $-\alpha\beta\gamma\tau \dfrac{d(\rho v)}{dy}$

" " " Z: $-\alpha\beta\gamma\tau \dfrac{d(\rho w)}{dz}$

---

resultierender [illegible] : $-\alpha\beta\gamma\tau\left[\dfrac{d(\rho u)}{dx}+\dfrac{d(\rho v)}{dy}+\dfrac{d(\rho w)}{dz}\right]$

[illegible] : $= \alpha\beta\gamma \dfrac{d\rho}{dt}\tau$

$$\left.\frac{d\rho}{dt} + \frac{d(\rho u)}{dx} + \frac{d(\rho v)}{dy} + \frac{d(\rho w)}{dz} = 0\right\}$$ [illegible] = Continuität

---

[illegible] $\parallel$ [illegible]

$v, w = 0$

[illegible]

$X, Y, Z = 0$

$$\begin{cases} -\dfrac{dp}{dx} = \rho\dfrac{du}{dt} + \rho u \dfrac{du}{dx} \quad \Big\| \quad -\dfrac{dp}{dy} = -\dfrac{dp}{dz} = 0 \\[2ex] \dfrac{d\rho}{dt} + \dfrac{d(\rho u)}{dx} = 0 \\[2ex] p = A.\rho^k \end{cases}$$ [illegible]

$p, \rho, u = ?$

$$-\frac{dp}{dx} = \rho\frac{du}{dt} + \rho u\frac{du}{dx}$$ [shorthand, illegible]

$$\frac{d\rho}{dt} + \frac{d(\rho u)}{dx} = 0$$

$$\rho = \rho_0 . (1+\sigma) \qquad \sigma = \text{[shorthand, illegible]}$$

$$-\frac{dp}{dx} = \rho_0\frac{du}{dt} + \left[\rho_0\sigma\frac{du}{dt} + \rho_0(1+\sigma)u\frac{du}{dx}\right.$$

[shorthand, illegible]

$$-\frac{dp}{dx} = \rho_0\frac{du}{dt} \quad \text{I).} \qquad \frac{d}{dx}\left[\text{------}\right]$$

$$\frac{d\rho}{dt} = \rho_0\frac{d\sigma}{dt} = -\frac{d}{dx}\left[\rho_0 u + \rho_0 u\sigma\right]$$

$$= -\rho_0\frac{du}{dx}$$

$$\frac{d\sigma}{dt} = -\frac{du}{dx} \quad \text{II).} \quad \frac{d}{dx}\left[\rho_0 \text{---}\right.$$

$$p = A\rho^k \qquad A \text{ [shorthand]}$$

$$p_0 = A\rho_0^k$$

$$\frac{p}{p_0} = \left(\frac{\rho}{\rho_0}\right)^k$$

$$\frac{p}{p_0} = (1+\sigma)^k = 1 + k\sigma + \text{------}$$

$$p = p_0\left[1 + k\sigma\right] \quad \text{III).}$$

$$\frac{d(\mathrm{I})}{dx} + \frac{d(\mathrm{III})\beta}{dt}$$

$$-\frac{d^2 p}{dx^2} + \rho_0 \frac{d^2\sigma}{dt^2} = 0$$

$$-p_0 k \frac{d^2\sigma}{dx^2} + \rho_0 \frac{d^2\sigma}{dt^2} = 0$$

$$\frac{d^2\sigma}{dt^2} = \frac{p_0 k}{\rho_0} \frac{d^2\sigma}{dx^2}$$ [illegible] transversal [illegible]

[illegible] longit. [illegible]

[illegible] R. S. [illegible] $k = 1$

$p_0 = 76 \cdot 13.59$ = [illegible]

$\times 980.6$ = [illegible] [[illegible]

$\rho_0 = 0.00129$

$\sqrt{\frac{p_0}{\rho_0}} \neq 27000$ cm = [illegible] [[illegible]]

[illegible] Newton [illegible]

[illegible] 332 m; [illegible]

[illegible] Laplace [illegible] R. S. [illegible]

[illegible]

[illegible]

[illegible] $\left(\frac{p}{p_0}\right) = \left(\frac{\rho}{\rho_0}\right)^k$ | $k = 1.4$

$k =$ [illegible] const. [illegible] : const. Vol.

$$\frac{d^2\sigma}{dt^2} = a^2 \frac{d^2\sigma}{dx^2} \qquad a^2 = \frac{p_0 k}{\rho_0}$$

$$\sigma = \sin \alpha t \left[A \cos \beta x + B \sin \beta x\right] +$$
$$+ \cos \alpha t \left[C \cos \beta x + D \sin \beta x\right]$$

$$\alpha^2 = a^2 \beta^2$$

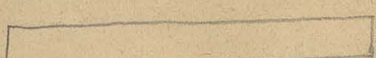
[illegible]

[illegible] σ

$x = 0 \quad u = 0 \qquad \frac{du}{dt} = 0$ [illegible] $\underline{s} = 0$

$x = l \quad u = 0$

$$\text{I} \quad \frac{du}{dx} = 0 \qquad \frac{d\sigma}{dx} = 0$$



$$\frac{d\sigma}{dx} = \sin \alpha t\left[-\beta A \sin \beta x + \beta B \cos \beta x\right] + \cos \alpha t\left[-\beta C \sin \beta x + \beta D \cos \beta x\right]$$

$$B = D = 0$$

$$\frac{d\sigma}{dx} = -\beta \sin \beta x \left[A \sin \alpha t + C \cos \alpha t\right]$$

$l \,|\,$ ~~$\sigma = 0$~~ $\sin \beta l = 0$

$$\beta l = \pi,\ 2\pi,\ 3\pi \ldots$$

$$\beta = \frac{\pi}{l},\ \frac{2\pi}{l} \ldots \qquad \Big|\ \alpha = \frac{a\pi}{l}, \ldots$$

[illegible]

[illegible]

$$\sigma = \cos \beta x \left[A \sin \alpha t + C \cos \alpha t \right]$$

$$p = p_0 (1 + k\sigma)$$

$$\frac{dp}{dx} = p_0 k \frac{d\sigma}{dx}$$

$$-p_0 k \frac{d\sigma}{dx} = \rho_0 \frac{du}{dt}$$

$$-a^2 \frac{d\sigma}{dx} = \frac{du}{dt}$$

$$\frac{du}{dt} = -a^2 \beta \sin \beta x \left[A \sin \alpha t + C \cos \alpha t \right]$$

$$u = -a^2 \beta \sin \beta x \frac{C \sin \alpha t - A \cos \alpha t}{\alpha}$$

$$u = a \sin \beta x \left[C \sin \alpha t - A \cos \alpha t \right]$$

[illegible] $x = 0$

$\beta x = \frac{\pi}{2}$ $\sigma = 0$ [illegible] $\beta =$

$x = \frac{l}{2}$ [illegible] $= 0$ [illegible]

[illegible] $x = 0$ $= 0$

[illegible] $x = \frac{l}{2}$

Octave:

$\sigma = \cos \frac{2\pi x}{l}$ [

$u = a \sin \frac{2\pi x}{l}$ [

$\sigma = 0 \quad \frac{2\pi x}{l} = \frac{\pi}{2} \quad x = \frac{l}{4}$

$x = \frac{3l}{4}$

< 0

> 0

$x = l$

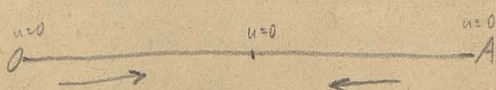
[illegible]



[illegible]

$x = 0$

$\frac{2\pi x}{l} = \pi \quad x = \frac{l}{2}$ } $u = 0$



[illegible]

[illegible]

20/5 Experimente: Longitud. [illegible]

[illegible]

$$\frac{d^2\sigma}{dx^2} = \frac{d^2\sigma}{dt^2}$$

[illegible]

I ✓: [illegible] $\sigma = 0$ [illegible]

[illegible]

$= 0$ [illegible]

$\sigma = 0$

$x = 0 \quad x = l$

[illegible]

$$\sigma = \sin\frac{\pi x}{l}\left[A_1 \cos\frac{\pi a t}{l} + B_1 \sin\frac{\pi a t}{l}\right] +$$

$$+ \sin\frac{2\pi x}{l}\left[A_2 \cos\frac{2\pi a t}{l} + B_2 \sin\frac{2\pi a t}{l}\right] + \cdots$$

[illegible], Octave etc.

$$-\frac{dp}{dx} = \rho_0 \frac{du}{dt} \qquad p = p_0(1 + k\sigma)$$

$$-p_0 k \frac{d\sigma}{dx} = \rho_0 \frac{du}{dt}$$

$$-a^2 \frac{d\sigma}{dx} = \frac{du}{dt}$$

$$\frac{du}{dt} = 0 \quad [illegible] \quad \frac{d\sigma}{dx} = 0 \qquad [illegible] \quad \sigma = \sin\frac{\pi x}{l}\left[\;\cdots\;\right]$$

$$\frac{d\sigma}{dx} = \frac{\pi}{l}\cos\frac{\pi x}{l}\left[\;\cdots\;\right]$$

$$\frac{\pi x}{l} = \frac{\pi}{2} \qquad \underline{x = \frac{l}{2}}$$ [illegible]

[illegible] $= 0$



Octave $\sigma = \sin\frac{2\pi x}{l}$ [—]

$$\frac{d\sigma}{dx} = \frac{2\pi}{l}\cos\frac{2\pi x}{l} \quad [\ —\ ]$$

$$\frac{d\sigma}{dx} = 0 \; : \quad \frac{2\pi x}{l} = \frac{\pi}{2}, \; \frac{3\pi}{2}$$

$$x = \frac{l}{4}, \; \frac{3l}{4}$$

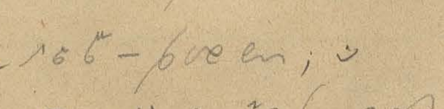


Quint Octave $\sigma = \sin\frac{3\pi x}{l}$ [—

$$\frac{d\sigma}{dx} = \frac{3\pi}{l}\cos\frac{3\pi x}{l} \quad [\ —\ ]$$

$$\frac{d\sigma}{dx} = 0 \; : \quad \frac{3\pi x}{l} = \frac{\pi}{2}, \; \frac{3\pi}{2}, \; \frac{5\pi}{2}$$

$$x = \frac{l}{6}, \; \frac{3l}{6}, \; \frac{5l}{6}$$



[illegible] = 0 [illegible]

[illegible]

[illegible] I [illegible]

[illegible] Octave [illegible] 3 [illegible]

[illegible]

[illegible]

[illegible]

$\sigma = \sin\alpha t\,[A\cos\beta x + B\sin\beta x]$

[illegible] $x=0$ [illegible] $x=l$ [illegible]:

$x=0 \quad \frac{du}{dt}=0 \quad = a^2\frac{d\sigma}{dx}=0$

$x=l \quad \sigma=0$

$\frac{d\sigma}{dx} = \sin\alpha t\,[-\beta A\sin\beta x + \beta B\cos\beta x]$

$B=0$

$\sigma = \sin\alpha t\,A\cos\beta x$

$0 = \sin\alpha t\,A\cos\beta l$

$\beta l = \frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}$ ---

$\beta = \frac{\pi}{2l}, \frac{3\pi}{2l}$, ---

[illegible], 3 [illegible], 5 [illegible] ...

[illegible] Bernoulli [illegible]

[illegible]: $x=l$, $\sigma=0$ [illegible] $\sigma=0$

[illegible]

[illegible] Octave [illegible]

[illegible] $\frac{1}{4}$ [illegible]

[illegible]

$$-\frac{dp}{dx} = \rho\left[\frac{du}{dt} + u\frac{du}{dx} + v\frac{du}{dy} + w\frac{du}{dz}\right]$$

$$-\frac{dp}{dx} = \rho\frac{du}{dt} \mp \rho_0\frac{du}{dt} \quad \parallel X$$

$$-\frac{dp}{dy} = \rho_0\frac{dv}{dt} \quad \parallel Y$$

$$-\frac{dp}{dz} = \rho_0\frac{dw}{dt} \quad \parallel Z$$

$$\frac{d\rho}{dt} = -\frac{d(\rho u)}{dx} - \frac{d(\rho v)}{dy} - \frac{d(\rho w)}{dz}$$

$$\rho_0\frac{d\sigma}{dt} = -\rho_0\left(\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz}\right)$$

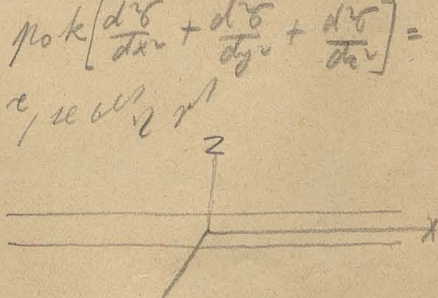
$$-\left[\frac{d^2p}{dx^2} + \frac{d^2p}{dy^2} + \frac{d^2p}{dz^2}\right] = \rho_0\frac{d}{dt}\left[\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz}\right]$$

$$= -\rho_0\frac{d^2\sigma}{dt^2}$$

$$p = p_0(1 + k\sigma)$$

$$p_0 k\left[\frac{d^2\sigma}{dx^2} + \frac{d^2\sigma}{dy^2} + \frac{d^2\sigma}{dz^2}\right] = \rho_0\frac{d^2\sigma}{dt^2}$$

[illegible]



[illegible] ∥ X [illegible]

[illegible] 3 Coord.

[illegible]

[illegible] $= 0$

2. [illegible]

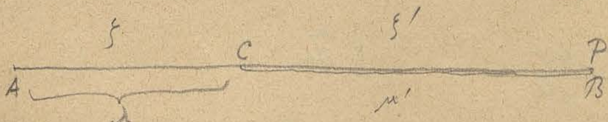
[illegible]

Helmholtz [illegible]

[illegible]

24/5 [illegible] 2 [illegible]

[illegible]



[illegible] CB [illegible] AC.

$$\mu \frac{d^2\xi}{dt^2} = P \frac{d^2\xi}{dx^2} \qquad \mu' \frac{d^2\xi'}{dt^2} = P \frac{d^2\xi'}{dx^2}$$

$$\frac{P}{\mu} = a^2 \quad \frac{P}{\mu'} = a'^2$$

$$\xi = [A \sin \alpha t + B \cos \alpha t][C \sin \beta x + \underline{D \cos \beta x}]$$

$$\left.\begin{matrix} x=0 \\ \xi = 0 \end{matrix}\right\} \qquad D = 0$$

$$\xi = \sin \beta x \, [F \sin \alpha t + B \cos \alpha t]$$

$$\alpha^2 = a^2 \beta^2$$

$$\xi' = [A' \sin \alpha' t + B' \cos \alpha' t][C' \sin \beta' x + D' \cos \beta' x]$$

[illegible] $\begin{matrix} x=0 \\ \xi=0 \end{matrix}$ [illegible]: $\left.\begin{matrix} x = l \\ \xi' = 0 \end{matrix}\right\}$

$$C' \sin \beta' l + D' \cos \beta' l = 0$$

$$\xi' = \left[A' \sin \alpha' t + B' \cos \alpha' t\right]\left[-\frac{D' \sin \beta' x \cos \beta' l}{\sin \beta' l} + D' \cos \beta' x\right]$$

$$= \left[\qquad \right] \left[\frac{D'}{\sin \beta' l} \sin \beta'(l-x)\right.$$

$$\xi' = \sin \beta'(l-x) \left[F' \sin \alpha' t + G' \cos \alpha' t\right]$$

$$\alpha' = a'\beta'$$

[illegible] C:

$x = \lambda \qquad \xi = \xi'$

$$\sin \beta \lambda \left[F \sin \alpha t + G \cos \alpha t\right] = \sin \beta' \lambda' \left[F' \sin \alpha' t + G' \cos \alpha' t\right]$$

$$l - \lambda = \lambda'$$

[illegible] $\alpha = \alpha'$: [illegible]

[illegible]

$$F \sin \beta \lambda = F' \sin \beta' \lambda'$$

$$G \sin \beta \lambda = G' \sin \beta' \lambda'$$

[illegible] contin. [illegible]

[illegible] m_1, [illegible]



$$m_1 \frac{d^2 \xi_1}{dt^2} = P \sin \alpha' - P \sin \alpha$$

$$= P \frac{d\xi'}{dx} - P \frac{d\xi}{dx}$$

[illegible] m_1 [illegible]

[illegible]

[illegible] conv. [illegible]

[illegible]

$x = \lambda$: $\quad p\frac{d\xi'}{dx} = p\frac{d\xi}{dx}$

$\frac{d\xi}{dx} = \frac{d\xi'}{dx}$ [illegible]

$$\beta\cos\beta\lambda\left[F\sin\alpha t + G\cos\alpha t\right] = -\beta'\cos\beta'\lambda'\left[F'\sin\alpha t + G'\cos\alpha t\right]$$

$$\begin{cases} \beta\cos\beta\lambda\, F = -\beta'\cos\beta'\lambda'\, F' \\ \beta\cos\beta\lambda\, G = -\beta'\cos\beta'\lambda'\, G' \end{cases}$$

$$\sin\beta\lambda\, F = \sin\beta'\lambda'\, F'$$

$$\sin\beta\lambda\, G = \sin\beta'\lambda'\, G'$$

$$\frac{\sin\beta\lambda}{\beta\cos\beta\lambda} = -\frac{\sin\beta'\lambda'}{\beta'\cos\beta'\lambda'}$$

$$\frac{\operatorname{tg}\beta\lambda}{\beta} = -\frac{\operatorname{tg}\beta'\lambda'}{\beta'}$$ — transc. [illegible]

$\beta\lambda = u \qquad \beta' a' = \beta a$

$$\beta' = \beta\frac{a}{a'}$$

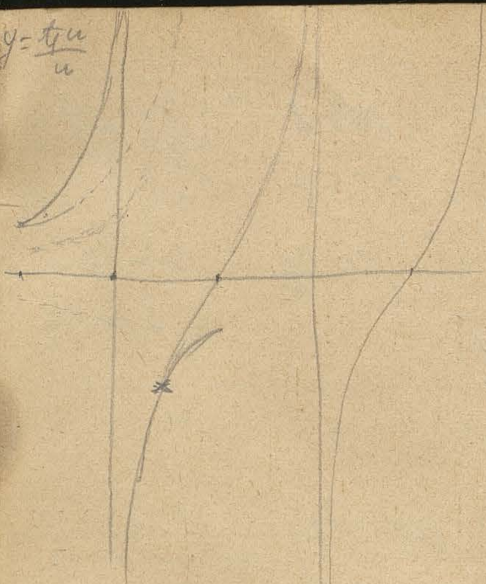
$$\beta'\lambda' = \beta\frac{a}{a'}\lambda' = u\frac{a\lambda'}{a'\lambda}$$

$$\lambda\frac{\operatorname{tg} u}{u} = -\frac{\operatorname{tg}\left(u\frac{a\lambda'}{a'\lambda}\right)}{\frac{a u}{a'\lambda}}$$

$$\frac{\operatorname{tg} u}{u}\lambda = -\frac{\operatorname{tg}\left(u\frac{a\lambda'}{a'\lambda}\right)}{u\frac{a\lambda'}{a'\lambda}}\lambda'$$

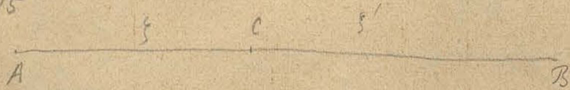
[illegible] s. const. [illegible]

$y = \frac{\operatorname{tg} u}{u}$



$y' = \frac{\lambda'}{\lambda} \frac{\operatorname{tg} u'}{u'}$

25/5



$\frac{d^2\xi}{dt^2} = a^2 \frac{d^2\xi}{dx^2}$ $\qquad \xi = F \sin \alpha t \sin \beta x$

$\xi' = F' \sin \alpha' t \sin \beta (l - x)$

[illegible]

$\alpha = \alpha'$

$\xi = \xi'$ $\quad \left| \begin{array}{l} x = \lambda \\ l - x = \lambda' \end{array} \right.$

$F \sin \beta \lambda = F' \sin \beta' \lambda'$

$\beta F \cos \beta \lambda = - F' \beta' \cos \beta' \lambda'$

$\frac{\operatorname{tg} \beta \lambda}{\beta} = - \frac{\operatorname{tg} \beta' \lambda'}{\beta'}$

[illegible]:

$\operatorname{tg} \beta\lambda = -\frac{\beta}{\beta'} \operatorname{tg} \beta'\lambda'$

$\alpha = a\beta$

$\alpha' = a'\beta'$

$\frac{\beta}{\beta'} = \frac{a'}{a}$

$= -\frac{a'}{a} \operatorname{tg} \beta'\lambda'$

$\beta' = \frac{\beta a}{a'}$

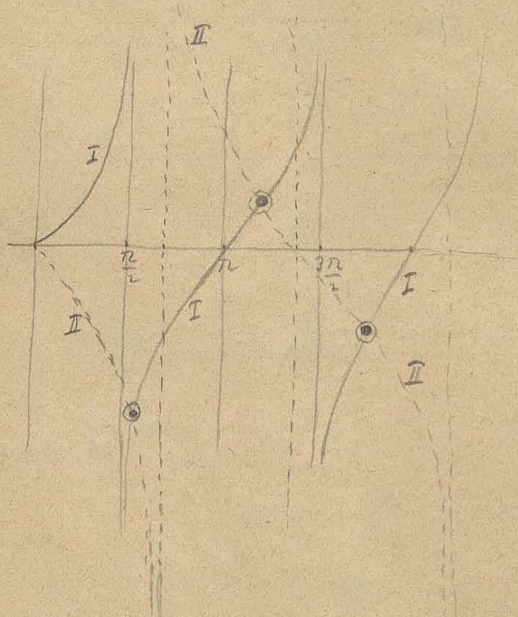
$\beta'\lambda' = \frac{\beta a}{a'}\lambda'$

$= \beta\lambda \frac{a\lambda'}{a'\lambda}$

$\operatorname{tg} \beta\lambda = -\frac{a'}{a} \operatorname{tg}\left[\beta\lambda \frac{a\lambda'}{a'\lambda}\right]$

$\operatorname{tg} y = -m \operatorname{tg} n y$

[illegible] geom. [illegible].



$\operatorname{tg} n y = \infty$

$n y = \frac{\pi}{2}$

$y = \frac{\pi}{2n}$

$n < 1 \quad y > \frac{\pi}{2}$

⊙ = [illegible]

[illegible] ∞ [illegible] 1, 2, 3 — [illegible]

[illegible] harmonisch [illegible]

[illegible] numerisch [illegible]:

[illegible]

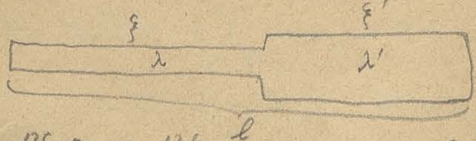
$tg\, y$	$tg\, ny$ z.B. $n = \frac{2}{3}$	$\frac{tg\, y}{tg\, ny}$
$tg\, 1^\circ$	$tg\, \frac{2}{3}{}^\circ$	
$tg\, 2^\circ$	$tg\, \frac{4}{3}{}^\circ$	

[illegible] + $tg\, y$ – $tg\, ny$ [illegible]

[illegible] Quotient = – m [illegible]

[illegible]

[illegible]



$$\frac{d^2\xi}{dt^2} = a^2 \frac{d^2\xi}{dx^2} \qquad a^2 = \frac{\mathfrak{E}}{\rho}$$

$$\frac{d^2\xi'}{dt^2} = a'^2 \frac{d^2\xi'}{dx^2} \qquad a' = \frac{\mathfrak{E}'}{\rho'}$$

$$\xi = A \sin \alpha t \cos \beta x \qquad x = 0 \quad \frac{d\xi}{dx} = 0$$

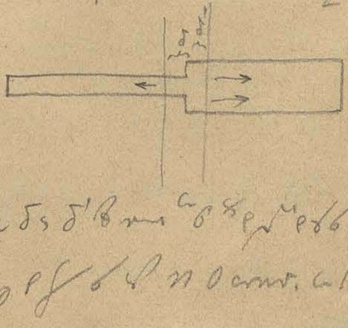
$$\xi' = A' \sin \alpha t \cos \beta'(l - x) \qquad \text{[illegible]}$$

$\alpha^2 = a^2 \beta^2$

$\alpha^2 = a'^2 \beta'^2$

1). [illegible] : $\xi = \xi'$

2). [illegible]:



[illegible] $= \xi_1$ [illegible]

$$\frac{d^2\xi_1}{dt^2}\left[q\rho\delta + q'\rho'\delta'\right] = \mathfrak{E}' q' \frac{d\xi'}{dx} - \mathfrak{E} q \frac{d\xi}{dx}$$

[illegible] δ, δ' [illegible] $= 0$ [illegible]

[illegible] $\frac{d^2\xi_1}{dt^2} = \infty$ [illegible]

$$\varrho q \frac{d\xi}{dx} = \varrho' q' \frac{d\xi'}{dx}$$

$$A \cos\beta\lambda = A' \cos\beta'\lambda'$$

$$-\beta \varrho q A \sin\beta\lambda = \varrho' q' A' \beta' \sin\beta'\lambda'$$

[illegible]

[illegible] β, β'; [illegible]

[illegible] β' [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] temp.

[illegible] Kautschuk [illegible] cca 50 m p. sec.

[illegible] Tannenh. 16× [illegible], Eisen 15× [illegible], [illegible] 9× [illegible].

[illegible]

27/5 $\frac{d^2\xi}{dt^2} = \frac{P}{\mu}\frac{d^2\xi}{dx^2}$ $\xi = \sin\frac{\pi x}{l}\left[A_1\cos\alpha_1 t + B_1\sin\alpha_1 t\right]$

$+ \sin\frac{2\pi x}{l}\left[A_2\cos\alpha_2 t + B_2\sin\alpha_2 t\right]$

[illegible] Superposition [illegible]

[illegible]

$\rho L k = \Sigma$ [illegible]

[illegible] $\rho L k$

$$\frac{d\xi}{dt} = \sin\frac{\pi x}{l}\left[-\alpha_1 A_1 \sin\alpha_1 t + \alpha_1 B_1 \cos\alpha_1 t\right]$$

$$+ \sin\frac{2\pi x}{l}\left[-\alpha_2 A_2 \sin\alpha_2 t + \alpha_2 B_2 \cos\alpha_2 t\right]$$

$$+ \cdots$$

$$\int_0^l \frac{\mu}{2}\left(\frac{d\xi}{dt}\right)^2 dx$$ = [illegible]

= [illegible]

$$\int_0^l \sin\frac{m\pi x}{l}\sin\frac{n\pi x}{l} = 0$$ [illegible]

[illegible]

[illegible]

$$\mu\frac{d^2\xi}{dt^2} = P\frac{d^2\xi}{dx^2}$$ [illegible]

$$\mu'\frac{d^2\xi'}{dt^2} = P'\frac{d^2\xi'}{dx^2}$$ [illegible]

$\xi =$ ~~$\sin t$~~ $\sin\alpha_1 t\, X_1 + \sin\alpha_2 t\, X_2 + \sin\alpha_3 t\, X_3$

$+ \cdots$

$\xi' = \sin\alpha_1 t\, X_1' + \sin\alpha_2 t\, X_2' + \cdots$

[illegible]

~~$\mu\frac{d^2\xi}{dt^2} = -\alpha_1^2 \sin\alpha_1 t$ P $\frac{d^2X_1}{dx^2} = 0$~~

$$-\mu\alpha_1^2 X_1 = P\frac{d^2X_1}{dx^2}$$

$$-\mu\alpha_2^2 X_2 = P\frac{d^2X_2}{dx^2}$$

$$-\mu'\alpha_1^2 X_1' = P'\frac{d^2X_1'}{dx^2}$$

[illegible]

$$\int_0^l X_1 X_2 \mu\, dx + \int_l^\lambda X_1' X_2' \mu' dx = 0$$

BW

$$\int_0^x X_1 X_2\, dx = \int X_1\left[\frac{P}{\mu\alpha_2^2}\frac{d^2X_2}{dx^2}\right]dx$$

$$-\mu\alpha_2^2 X_2 = P\frac{d^2X_2}{dx^2}$$

$$= \frac{-P}{\mu\alpha_2^2}\int X_1\frac{d^2X_2}{dx^2}dx = -\frac{P}{\mu\alpha_2^2}\left[X_1\frac{dX_2}{dx} - \int\frac{dX_1}{dx}\frac{dX_2}{dx}dx\right]$$

$$= -\frac{P}{\mu\alpha_2^2}\left[X_1\frac{dX_2}{dx} - X_2\frac{dX_1}{dx} + \int X_2\frac{d^2X_1}{dx^2}dx\right]$$

$$= -\frac{P}{\mu\alpha_2^2}\left[X_1\frac{dX_2}{dx} - X_2\frac{dX_1}{dx} - \frac{\mu\alpha_1^2}{P}\int X_2 X_1\, dx\right]$$

$$\int X_1 X_2\, dx = -\frac{P}{\mu\alpha_2^2}\left[X_1\frac{dX_2}{dx} - X_2\frac{dX_1}{dx}\right] + \frac{\alpha_1^2}{\alpha_2^2}\int X_1 X_2\, dx$$

$$\mu(\alpha_2^2-\alpha_1^2)\int_0^\lambda X_1 X_2\, dx = -P\left[X_1\frac{dX_2}{dx} - X_2\frac{dX_1}{dx}\right]_0^\lambda$$

$$\mu'(\alpha_2^2-\alpha_1^2)\int_\lambda^l X_1' X_2' \, dx = -P'\left[X_1'\frac{dX_2'}{dx} - X_2'\frac{dX_1'}{dx}\right]_\lambda^l$$

$x=0$ $\xi=0$ $\quad X_1=0 \quad X_2=0$

$x=l$ $\xi'=0$ $\quad X_1'=0 \quad X_2'=0$

$$(\alpha_2^2-\alpha_1^2)\left[\mu\int_0^\lambda X_1 X_2\,dx + \mu'\int_\lambda^l X_1' X_2'\,dx\right] =$$

$$= -P\left[X_1\frac{dX_2}{dx} - X_2\frac{dX_1}{dx}\right]$$

$$= +P\left[X_1'\frac{dX_2'}{dx} - X_2'\frac{dX_1'}{dx}\right]$$

$x=\lambda \quad \frac{d\xi}{dx} = \frac{d\xi'}{dx}$

[illegible]

[illegible]

[illegible]

zB.

[illegible]



[illegible]

31/5 D'Alembert :

$$\frac{d^2\xi}{dt^2} = a^2 \frac{d^2\xi}{d\xi^2}$$ [illegible]

$$\xi = f(x - at)$$

$$\frac{\partial \xi}{\partial x} = f'(x-at) \qquad \frac{\partial \xi}{\partial t} = -af'(x-at)$$

$$\frac{\partial^2 \xi}{\partial x^2} = f''(x-at) \qquad \frac{\partial^2 \xi}{\partial t^2} = a^2 f''(x-at)$$

$$\frac{\partial^2 f}{\partial x^2} = \text{—}$$

[illegible] $-a$ [illegible] $+a$

[illegible] $F(x+at)$

$$\xi = f(x-at) + F(x+at)$$

[illegible].

$$\xi = a \sin \frac{\pi x}{l} \sin \frac{a\pi t}{l}$$

$$= \frac{a}{2}\left[\cos \frac{\pi}{l}(x-at) + \cos \frac{\pi}{l}(x+at)\right]$$

$t=0 \qquad \xi = \varphi(x)$

$$\frac{\partial \xi}{\partial t} = \psi(x)$$

$$\frac{d\xi}{dt} = -a\left[f'(x-at) + a\,F(x+at)\right.$$

$t=0 \;|\; \varphi$

$$\varphi(x) = f(x) + F(x)$$

$$\psi(x) = [-f'(x) + F'(x)]a$$

$$\int_0^x \psi(x)\,dx = -a\int_0^x f'(x)\,dx + a\int_0^x F'(x)\,dx$$

$$= -a f(x)\Big|_0^x + a F(x)\Big|_0^x$$

$$= -a f(x) + a f(0) + a F(x) - a F(0)$$

C

$$C + \int_0^x \psi(x)\,dx = -a f(x) + a F(x)$$

$$C + \int_0^x \psi(y)\,dy = -a f(x) + a F(x)$$

$$f(x) + F(x) = \varphi(x)$$

$$-f(x) + F(x) = \frac{1}{a}\left[\int_0^x \psi(y)\,dy + \frac{C}{a}\right.$$

$$F(x) = \frac{1}{2}\varphi(x) + \frac{1}{2a}\int_0^x \psi(y)\,dy + \frac{C}{2a}$$

$$f(x) = \frac{1}{2}\varphi(x) - \frac{1}{2a}\int_0^x \psi(y)\,dy - \frac{C}{2a}$$

$$\xi = \frac{1}{2}\varphi(x-at) + \frac{1}{2a}\int_0^{x-at} \psi(y)\,dy + \frac{1}{2}\varphi(x+at) + \frac{1}{2a}\int_0^{x+at}\psi(y)\,dy$$

$$-\frac{1}{2a}\int_0^{x-at}\psi(y)\,dy = \frac{1}{2a}\int_{x-at}^0$$

$$\xi = \frac{1}{2}\varphi(x-at) + \frac{1}{2}\varphi(x+at) + \frac{1}{2a}\int_{x-at}^{x+at}\psi(y)\,dy$$

$t=0$

$$\xi = \frac{1}{2}\varphi(x) + \frac{1}{2}\varphi(x) + \frac{1}{2a}\int_{x}^{x}\psi(y)\,dy = \varphi(x)$$

$$\frac{d\xi}{dt} = -\frac{a}{2}\varphi'(x-at) + \frac{a}{2}\varphi'(x+at) + \frac{1}{2a}\Big[\psi(x+at)a + \psi(x-at)a\Big]$$

$t=0$

$$\frac{d\xi}{dt} = \frac{1}{2a}\Big[\psi(x)a + \psi(x)a\Big] = \psi(x)$$

[illegible] $\psi(x)$ [illegible].

[illegible] $|0-l|$ [illegible]

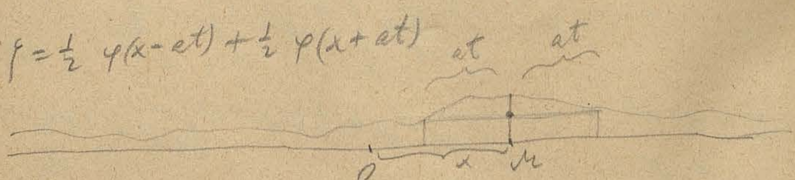
[illegible] $-\infty$ [illegible] $+\infty$.

[illegible] $\left.\begin{matrix} x=0 \\ x=0 \end{matrix}\right\}$ $\xi=0$

[illegible]:

$t=0$ $\xi=\varphi(x)$

$$\xi = \frac{1}{2}\varphi(x-at) + \frac{1}{2}\varphi(x+at)$$



[illegible] O [illegible] M [illegible] M [illegible] $\frac{1}{2}$ }
[illegible]



[illegible]

$\varphi(x) \gtrless 0 \quad \Big| \; x \lessgtr \begin{cases} -\frac{\lambda}{2} \\ +\frac{\lambda}{2} \end{cases}$

$x_1 > \frac{\lambda}{2}$

$$\zeta = \frac{1}{2}\,\varphi(x_1 - at) + \underbrace{\frac{1}{2}\,\varphi(x_1 + at)}_{=0}$$

[illegible] $x_1 - at \gtrless \begin{cases} -\frac{\lambda}{2} \\ +\frac{\lambda}{2} \end{cases}$

1/6 [illegible]

[illegible] ?



16 [illegible]

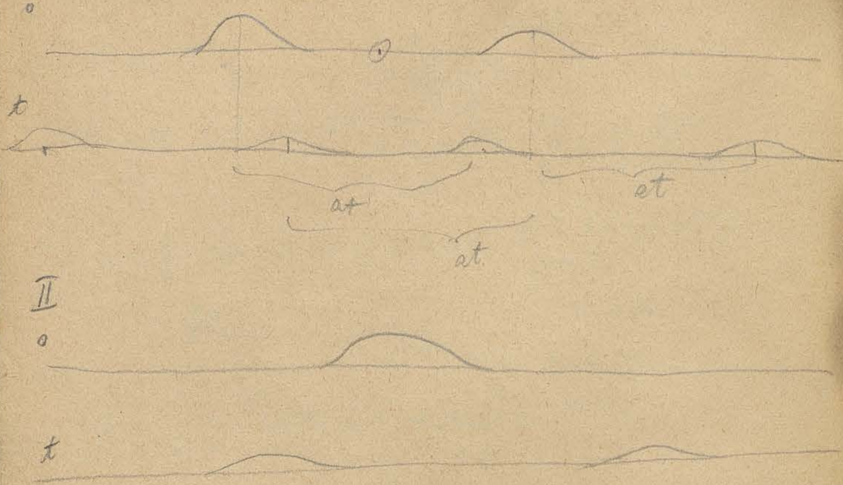


[illegible] $-\frac{1}{2}$.

[illegible] a.

$\varphi(x - at) =$ [illegible] $+ X$ [illegible]

$\varphi(x + at) =$ —



I_0 [illegible] $II\ t$ [illegible]

$I\ 0 \qquad \varphi(x) \parallel \qquad \psi(x) = 0$

$II\ t \qquad \varphi(x) \parallel \qquad \psi(x) \gtrless 0.$

[illegible]:

$\xi = \frac{1}{2}\ \varphi(x-at)$

$\frac{d\xi}{dt} = -\frac{a}{2}\ \varphi'(x-at)$

[illegible]:

$\xi = \frac{1}{4}\ \varphi(x-at) + \frac{1}{4}\ \varphi(x+at) + \frac{1}{4a}\int_{x-at}^{x+at} \varphi'(y)\,dy$

$= \frac{1}{4}\ \varphi(x-at) + \frac{1}{4}\ \varphi(x+at) - \frac{1}{4}\ \varphi(x+at) + \frac{1}{4}\ \varphi(x-at)$

$= \frac{1}{2}\ \varphi(x-at)$ [illegible]

$t=0 \quad \xi = \frac{\varphi(x)}{2}$ [illegible]

[illegible] longitudinal [illegible]

$a\sqrt{\frac{P}{\mu}}$ $a=\sqrt{\frac{q}{\rho}}$ $a=\sqrt{\frac{p}{\rho}k}$

[illegible]



$$\xi=\tfrac{1}{2}\,\varphi(x-at)+\tfrac{1}{2}\,\varphi(x+at)$$

[illegible]

[illegible] $=0$ | [illegible] Constr. [illegible]

[illegible]

$$\xi=\tfrac{1}{2}\,\varphi(-at)+\tfrac{1}{2}\,\varphi(at)=0$$

$$\varphi(-at)=-\varphi(at)$$

$$\varphi(-x)=-\varphi(x)$$



[illegible] ∞ [illegible] ∞ [illegible]

[illegible]

[illegible] refl. [illegible]

2/6



[illegible]

$t=0$



[illegible] etc.

z.B.

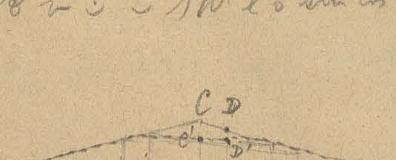


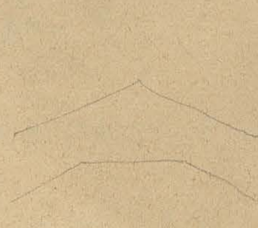
[illegible] per. [illegible]

$at = 2l$

$\tau = \frac{2l}{a} =$ [illegible] $\qquad n = \frac{a}{2l} = \frac{1}{2l}\sqrt{\frac{P}{\mu}}$

[illegible] sin [illegible] etc.







[illegible]

[illegible] $at = \frac{l}{2}$ [illegible]

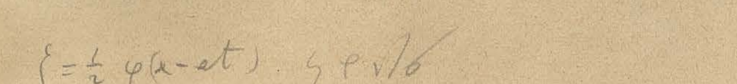
[illegible]



IV [illegible]

[illegible]





$$\xi = \frac{1}{2}\,\varphi(x - at) + \frac{1}{2}\,\varphi(x + at)$$

$$\xi = \frac{1}{2}\,\varphi(x - at)$$ [illegible]

$$\frac{d\xi}{dt} = -\frac{a}{2}\,\varphi'(x - at)$$ [illegible]

[illegible] D'Alembert [illegible] Euler [illegible] | Lagrange(s) Fourier [illegible]

[illegible] per. [illegible] Bernoulli [illegible]

[illegible]

[illegible]



[illegible]

$x=0 \quad \xi = f(t)$ | $t=0 \quad \frac{d\xi}{dt}=0$

$$\xi = \tfrac{1}{2}\varphi(x-at) + \tfrac{1}{2}\varphi(x+at)$$

$x=0 \quad \xi = f(t)$

$$f(t) = \tfrac{1}{2}\varphi(-at) + \tfrac{1}{2}\varphi(at) \qquad at=y$$

$$f\left(\tfrac{y}{a}\right) = \tfrac{1}{2}\varphi(-y) + \tfrac{1}{2}\varphi(y)$$

$$\varphi(-y) = 2f\left(\tfrac{y}{a}\right) - \varphi(y)$$ [illegible]

3/6



$x=0 \quad \xi = f(t)$

$$\xi = \tfrac{1}{2}\varphi(x-at) + \tfrac{1}{2}\varphi(x+at)$$

$t=0 \quad \xi = \varphi(x)$

$$f(t) = \tfrac{1}{2}\varphi(-at) + \tfrac{1}{2}\varphi(at)$$

$$\varphi(-at) = 2f(t) - \varphi(at)$$

$\varphi(-y) = 2f(y/a) - \varphi(y)$

[illegible] $\varphi(y) = 0 \quad y > 0$ [illegible] $t = 0$ [illegible]



$\zeta = \frac{1}{2}\varphi(x - at)$

$= \frac{1}{2}\varphi[-(at - x)]$

$= f\left(\frac{at - x}{a}\right)$

$at - x$ [illegible]

$\varphi(-y) = 2f(y/a)$

$\zeta = f\left(t - \frac{x}{a}\right) \qquad x = 0 \quad \zeta = f(t)$

[illegible] $t=0$ [illegible]

[illegible] t [illegible] $t - \frac{x}{a}$ [illegible]

[illegible] t [illegible] M [illegible] $= \frac{x}{a}$



[illegible] A [illegible]

[illegible] A [illegible] O' [illegible]

[illegible]

[illegible]

[illegible]

[illegible] $= 2\alpha$

$$\xi = f\left(t - \frac{x}{a}\right) - f\left(t - \frac{l + \Delta l}{a}\right) + f\left(t - \frac{2l + x}{a}\right) \dots$$

$$\xi = f\left(t - \frac{x}{a}\right) - f\left(t - \frac{2l - x}{a}\right) + f\left(t - \frac{2l + x}{a}\right) -$$

$$- f\left(t - \frac{4l - x}{a}\right) + f\left(t - \frac{4l + x}{a}\right) - \dots$$

[illegible] $f(\ )$ [illegible]

$x = 0 \qquad \xi = f(t)$

$x = l \qquad \xi = 0$

[illegible] $f(t) = A \sin \alpha t$

$$\xi = A \sin \alpha\left(t - \frac{x}{a}\right) - A \sin\alpha\left(t - \frac{2l - x}{a}\right) +$$

$$+ A \sin\alpha\left(t - \frac{2l + x}{a}\right) - A \sin\alpha\left(t - \frac{4l - x}{a}\right) +$$

$$+ A \sin\alpha\left(t - \frac{4l + x}{a}\right) - \dots$$

$$= A \sin\alpha\left(t - \frac{x}{a}\right) - 2A \cos\alpha\left(t - \frac{2l}{a}\right) \sin\frac{\alpha x}{a} -$$

$$- 2A \cos\alpha\left(t - \frac{4l}{a}\right) \sin\frac{\alpha x}{a} - 2A \cos\alpha\left(t - \frac{6l}{a}\right) \sin\frac{\alpha x}{a} - \dots$$

[illegible]

[illegible] $x = 0$ $\xi = 0$ [illegible]

[illegible] $\frac{\alpha 2l}{a} = \pi$

$$\xi = A \sin\alpha\left(t - \frac{x}{a}\right) - 2A \sin\frac{\alpha x}{a} \cos\alpha t \left[\cos\alpha\frac{2l}{a} + \cos\alpha\frac{4l}{a} + \cos\alpha\frac{6l}{a} + \dots\right]$$

$$- 2A \sin\frac{\alpha x}{a} \sin\alpha t \left[\sin\alpha\frac{2l}{a} + \sin\alpha\frac{4l}{a} + \dots\right]$$

[illegible]

[illegible] $\frac{\alpha 2l}{a} = 2\pi$

$$\xi = A \sin\alpha\left(t - \frac{x}{a}\right) - 2A \sin\frac{\alpha x}{a} \cos\alpha t \left[\cos 2\pi + \cos 4\pi + \cos 6\pi + \dots\right] - \dots$$

[illegible] $< \dots / \infty$ [illegible] t / ∞

[illegible]

[illegible] $/ \infty$ [illegible] 1). [illegible]

2). [illegible]

[illegible] Resonanz

[illegible] Reson [illegible] $\frac{\alpha 2l}{a} = 2\pi$

$\xi = a \sin\alpha t$ $\alpha =$

$\alpha = 2\pi n$ $\frac{2\pi n\, 2l}{a} = 2\pi$

$$n = \frac{a}{2l} = \frac{1}{2l}\sqrt{\frac{P}{\mu}}$$

[illegible]

$$\xi = A \sin \alpha \left(t - \frac{x}{a}\right) - 2A \sin \frac{\pi x}{l} \cos \alpha t \left[1 + 1 + \ldots\right.$$

[illegible] $x=0$, $x=l$ [illegible]

[illegible]

[illegible]

[illegible] $\frac{2\alpha l}{a} = 4\pi$, [illegible]

[illegible]

= Oct. etc.
[illegible]

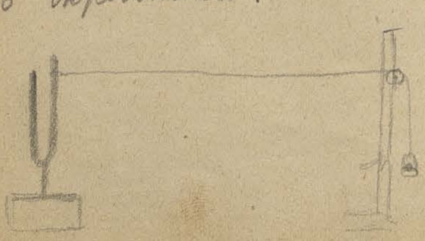
[illegible]

[illegible]

[illegible]

9/6 Experimente:

[illegible]



[illegible] transv. [illegible] long. [illegible] $\frac{1}{2}$ [illegible]

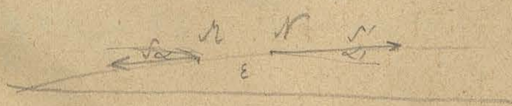


[illegible]



[illegible] long. [illegible] transv. [illegible]

? [illegible] ?



$$S'\sin\alpha' - S\sin\alpha = \mu\, MN\, \frac{d^2\zeta}{dt^2}$$

$$\left(-\omega\, MN \frac{d\zeta}{dt}\right) \quad [= \ldots]$$

~~$S'\sin\alpha' - S$~~

$$\mu \frac{d^2\zeta}{dt^2} = \frac{S'\sin\alpha' - S\sin\alpha}{MN} - \omega \frac{d\zeta}{dt}$$

$$= \frac{d}{dx}(S\sin\alpha) - \omega \frac{d\zeta}{dt}$$

$$\mu \frac{d^2y}{dt^2} = \frac{d}{dx}\left(S\frac{dy}{dx}\right) - \omega\frac{dy}{dt}$$

$$S = P + Q_g x$$

$$= \frac{d}{dx}\left(P\frac{dy}{dx}\right) - \omega\frac{dy}{dt}$$

$$\mu\frac{d^2y}{dt^2} = P\frac{d^2y}{dx^2} - \omega\frac{dy}{dt}$$

$$\frac{d^2y}{dt^2} = a^2\frac{d^2y}{dx^2} - 2b\frac{dy}{dt}$$

$a^2 = \frac{P}{\mu}$
$\frac{\omega}{\mu} = 2b$

10/6 $$\frac{d^2y}{dt^2} = a^2\frac{d^2y}{dx^2} - 2b\frac{dy}{dt}$$

[illegible]

$y = \sin\beta x . T$ $\qquad T = ?$

$$\sin\beta x \frac{d^2T}{dt^2} = -\beta^2a^2 \sin\beta x\, T - 2b \sin\beta x \frac{dT}{dt}$$

$$\frac{d^2T}{dt^2} = -\beta^2a^2T - 2b\frac{dT}{dt}$$ [illegible] pert. [illegible]

$T = e^{\alpha t}$

$$\alpha^2 e^{\alpha t} = -\beta^2a^2 e^{\alpha t} - 2b\alpha e^{\alpha t}$$

$$\alpha^2 + 2b\alpha = -\beta^2a^2$$

$$\alpha = -b \pm \sqrt{b^2 - \beta^2a^2}$$; 2 [illegible]

we $b > \beta a$ [illegible]

[illegible] $b < \beta a$

$$\alpha = -b \pm i\underbrace{\sqrt{\beta^2 a^2 - b^2}}_{\gamma}$$

$$T = e^{-bt+\gamma t i} \quad \Big| \; C$$

$$+ e^{-bt-\gamma t i} \quad \Big| \; D$$

$$T = e^{-bt}\left[A\cos\gamma t + B\sin\gamma t\right]$$

[illegible] $\alpha =$

$$\gamma \tau = 2\pi$$

$$\tau = \frac{2\pi}{\gamma} \qquad n = \frac{1}{\tau} = \frac{\gamma}{2\pi}$$

$$\tau = \frac{2\pi}{\sqrt{\beta^2 a^2 - b^2}}$$

[illegible] $b = 0$ [illegible]

$b > 0$ $\quad \tau >$

[illegible]

[illegible]

[illegible]:

[illegible] Ampl [illegible]

[illegible]

$\xi = f(t - \frac{x}{a})$ [illegible]

$\xi = e^{-hx} f(t - \frac{x}{c})$ [illegible]?

$$\frac{d\xi}{dt} = e^{-hx} f'(t - \tfrac{x}{c}) \qquad \frac{d^2\xi}{dt^2} = e^{-hx} f''(t - \tfrac{x}{c})$$

$$\frac{dy}{dx} = -h\, e^{-hx} f\left(t-\frac{x}{c}\right) - \frac{1}{c}\, e^{-hx} f'\left(t-\frac{x}{c}\right)$$

$$\frac{d^2y}{dx^2} = h^2 e^{-hx} f\left(t-\frac{x}{c}\right) + \frac{h}{c}\, e^{-hx} f'\left(t-\frac{x}{c}\right) + \frac{h}{c}\, e^{-hx} f'\left(t-\frac{x}{c}\right) +$$

$$+ \frac{1}{c^2}\, e^{-hx} f''\left(t-\frac{x}{c}\right)$$

$$e^{-hx} f''\left(t-\frac{x}{c}\right) = a^2 h^2 e^{-hx} f(t-\ ) + 2\frac{a^2h}{c}\, e^{-hx} f'(\ ) +$$

$$+ \frac{a^2}{c^2}\, e^{-hx} f''(\ ) - 2b\, e^{-hx} f'(\ ).$$

[illegible] $b=0$ [illegible] $h=0$

[illegible]: $f'' = a^2h^2 f + 2\frac{a^2h}{c} f' + \frac{a^2}{c^2} f'' - 2b f'$

$b=0$ $\quad f'' = \frac{a^2}{c^2} f''$

$a = c$ [illegible]

[illegible]

[illegible]

[illegible]: $\frac{2a^2h}{c} = 2b$

$h = \frac{bc}{a^2}$ [illegible]:

$f'' = a^2h^2 f + \frac{a^2}{c^2} f''$ [illegible]

[illegible]

[illegible]

$$f = A \sin\alpha\left(t - \frac{x}{c}\right)$$

$$-\alpha^2 A \sin\alpha\left(t - \frac{x}{c}\right) = a^2 b^2 A \sin - + \frac{a^2}{c^2}\alpha^2 A \sin$$

$$-\alpha^2 = a^2 b^2 - \frac{\alpha^2 a^2}{c^2}$$

$$1 = \frac{a^2}{c^2} - \frac{a^2 b^2}{\alpha^2} = \frac{a^2}{c^2} - \frac{a^2}{\alpha^2}\frac{b^2 c^2}{a^4}$$

[illegible]

$$c^2 = a^2 - \frac{b^2}{\alpha^2 a^2} c^4$$

[illegible]

$$c^2 = a^2 - \frac{b^2 a^2}{\alpha^2}$$

$$\alpha = \frac{2\pi}{\tau} \qquad c^2 = a^2 - \frac{b^2 a^2}{4\pi^2}\tau^2$$

[illegible]

[illegible] Fouriers [illegible] [illegible] Optik Dispersion 26.

$$\beta_m a^2 - b^2 = \beta_m c^2$$

$$c^2 = a^2 - \frac{b^2}{\beta_m}$$

14/6 [illegible]

[illegible]:

$$-\frac{1}{\rho}\frac{dp}{dx} = \frac{du}{dt} + \underline{u\frac{du}{dx} + v\frac{du}{dy} + w\frac{du}{dz}}$$

[illegible]

$$-\frac{1}{\rho}\frac{dp}{dx} = \frac{du}{dt} \qquad \rho = \rho_0(1+\sigma)$$

$$-\frac{dp}{dx} = \rho_0(1+\sigma)\frac{du}{dt} \doteq \rho_0\frac{du}{dt}$$

$$\text{I.}\begin{cases} -\dfrac{dp}{dx} = \rho_0\dfrac{du}{dt} \\ -\dfrac{dp}{dy} = \rho_0\dfrac{dv}{dt} \\ -\dfrac{dp}{dz} = \rho_0\dfrac{dw}{dt} \end{cases}$$

$$\frac{d\rho}{dt} + \frac{d(\rho u)}{dx} + \frac{d(\rho v)}{dy} + \frac{d(\rho w)}{dz} = 0$$

$$\rho = \rho_0(1+\sigma)$$

$$\rho_0\frac{d\sigma}{dt} + \frac{d}{dx}(\rho_0 u + \rho_0 u\sigma) + \text{———}$$

$$\frac{d\sigma}{dt} + \frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz} = 0$$

$$\frac{d\sigma}{dt} + \frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz} = 0 \Big\} \ II.$$

$$\frac{p}{p_0} = \left(\frac{\rho}{\rho_0}\right)^k$$

$$p = p_0 (1+\sigma)^k = p_0 (1 + k\sigma) \Big\} \ III$$

$$I.: \quad -\frac{\partial^2 p}{\partial x^2} - \frac{\partial^2 p}{\partial y^2} - \frac{\partial^2 p}{\partial z^2} = \rho_0 \frac{\partial}{\partial t}\left[\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}\right]$$

$$= -\rho_0 \frac{\partial^2 \sigma}{\partial t^2}$$

$$p_0 k \left[\frac{\partial^2 \sigma}{\partial x^2} + \text{———} \right] = \rho_0 \frac{d^2 \sigma}{dt^2}$$

$$\frac{p_0 k}{\rho_0} = a^2$$

$$IV. \quad \frac{d^2\sigma}{dt^2} = a^2 \left[\frac{d^2\sigma}{dx^2} + \frac{d^2\sigma}{dy^2} + \frac{d^2\sigma}{dz^2}\right]$$

[illegible]

[illegible]

[illegible] IV [illegible]

$$\sigma = \varphi(r, t) \qquad r^2 = x^2 + y^2 + z^2$$

$$\frac{d\sigma}{dx} = \frac{d\sigma}{dr}\frac{dr}{dx} = \frac{d\sigma}{dr}\frac{x}{r} \quad \Big| \quad \frac{d^2\sigma}{dx^2} = \frac{d^2\sigma}{dr^2}\frac{dr}{dx}\frac{x}{r} + \frac{d\sigma}{dr}\frac{1}{r} +$$

$$+ \frac{d\sigma}{dr}\frac{x}{r^2}\frac{dr}{dx}$$

$$\frac{d^2\sigma}{dx^2} = \frac{d^2\sigma}{dr^2}\frac{x^2}{r^2} + \frac{d\sigma}{dr}\frac{1}{r} - \frac{d\sigma}{dr}\frac{x^2}{r^3}$$

$$\frac{d^2\sigma}{dx^2} + \frac{d^2\sigma}{dy^2} + \frac{d^2\sigma}{dz^2} = \frac{d^2\sigma}{dr^2}\frac{x^2}{r^2} + \frac{d\sigma}{dr}\frac{1}{r} - \frac{d\sigma}{dr}\frac{x^2}{r^3}$$

$$+ \frac{d^2\sigma}{dr^2}\frac{y^2}{r^2} + \frac{d\sigma}{dr}\frac{1}{r} - \frac{d\sigma}{dr}\frac{y^2}{r^3}$$

$$+ \frac{d^2\sigma}{dr^2}\frac{z^2}{r^2} + \frac{d\sigma}{dr}\frac{1}{r} - \frac{d\sigma}{dr}\frac{z^2}{r^3}$$

$$= \frac{d^2\sigma}{dr^2} + \frac{2}{r}\frac{d\sigma}{dr}$$

IV. $$\frac{d^2\sigma}{dt^2} = a^2\left[\frac{d^2\sigma}{dr^2} + \frac{2}{r}\frac{d\sigma}{dr}\right]$$

$$r\frac{d^2\sigma}{dt^2} = a^2\left[r\frac{d^2\sigma}{dr^2} + 2\frac{d\sigma}{dr}\right]$$

$$\underbrace{r\frac{d^2\sigma}{dr^2} + \frac{d\sigma}{dr}} + \frac{d\sigma}{dr}$$

$$= \frac{d}{dr}\left(r\frac{d\sigma}{dr}\right) + \frac{d\sigma}{dr} = \frac{d}{dr}\left[r\frac{d\sigma}{dr} + \sigma\right]$$

$$= \frac{d}{dr}\left[\frac{d}{dr}(r\sigma)\right] = \frac{d^2(r\sigma)}{dr^2}$$

$$r\frac{d^2\sigma}{dt^2} = a^2\frac{d^2(r\sigma)}{dr^2}$$

$$\frac{d^2(r\sigma)}{dt^2} = a^2\frac{d^2(r\sigma)}{dr^2}$$ [illegible]

~~$r\sigma = M f\left(t - \frac{r}{a}\right)$~~ $r = 0$ [illegible] $f' = 0$; [illegible]

[illegible]

$r\sigma = r_0 f\left(t - \frac{r_0}{a}\right)$

$r = r_0 \,|\quad \sigma = f(t)$ [illegible] $r = r_0$ [illegible]

[illegible] $f(t)$ [illegible]

$$\sigma = \frac{r_0}{r} f\left(t - \frac{r - r_0}{a}\right)$$

[illegible] ft [illegible]

[illegible] $f(t)$; [illegible] $\sigma = f(t)$ $r = r_0$

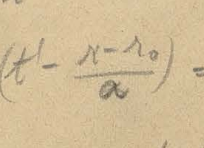
$= A \sin \alpha t$

$$\sigma = A \frac{r_0}{r} \sin\alpha\left(t' - \frac{r - r_0}{a}\right)$$

[illegible]:

$$\alpha\left(t' - \frac{r - r_0}{a}\right) = \alpha t$$

$$t' - t = \frac{r - r_0}{a}$$ [illegible] t'



[illegible]

[illegible]

[illegible] $\frac{r_0}{r}$; [illegible] (r_0) [illegible] Ampl. A; [illegible]

[illegible]

[illegible]

$$\rho_0 \frac{du}{dt} = -\frac{dp}{dx}$$

$$= -\frac{dp}{dr}\frac{dr}{dx} = -\frac{dp}{dr}\frac{x}{r}$$

$$\frac{du}{dt} = -\frac{1}{\rho_0}\frac{dp}{dr}\frac{x}{r}$$

$\frac{x}{r}$ [illegible] cos.

$$\frac{dv}{dt} = -\frac{1}{\rho_0}\frac{dp}{dr}\frac{y}{r}$$

$$\frac{dw}{dt} = -\frac{1}{\rho_0}\frac{dp}{dr}\frac{z}{r}$$

[illegible] Res. [illegible]

[illegible] RV. [illegible]

[illegible] RV. [illegible] longit.

15/6 [illegible] RV. [illegible]

[illegible]

$$\frac{d^2\sigma}{dt^2} = a^2\left[\frac{d^2\sigma}{dx^2} + \frac{d^2\sigma}{dy^2} + \frac{d^2\sigma}{dz^2}\right]$$

$$\sigma = f\left[t - \frac{(x\cos\lambda + y\cos\mu + z\cos\nu)}{a}\right]$$

[illegible] perp. P

$$= f\left(t - \frac{P}{a}\right) \qquad P = x\cos\lambda + y\cos\mu + z\cos\nu$$

$$\frac{d^2\sigma}{dt^2} = f''\left(t - \frac{P}{a}\right)$$

$$\frac{d\sigma}{dx} = f'\left(t - \frac{P}{a}\right)\left[-\frac{\cos\lambda}{a}\right]$$

$$\frac{d^2\sigma}{dx^2} = f''\left(t - \frac{P}{a}\right)\frac{\cos^2\lambda}{a^2}$$

$$f''\left(t - \frac{P}{a}\right) = a^2 f''\left(t - \frac{P}{a}\right)\frac{\cos^2\lambda + \cos^2\mu + \cos^2\nu}{a^2}$$

$$= f''\left(t - \frac{P}{a}\right)$$

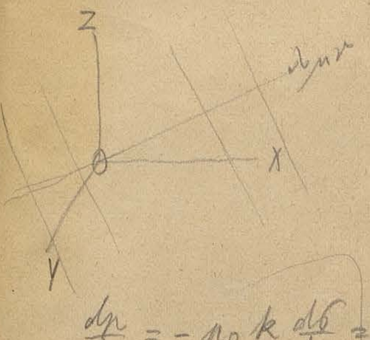
[illegible] $\sigma \sim$ [illegible]

[illegible]

$$\sigma = A \sin\alpha\left(t - \frac{x\cos\lambda + y\cos\mu + z\cos\nu}{a}\right)$$

[illegible]

[illegible] YZ [illegible]



$x = 0$

$u = 0$

$$-\frac{dp}{dx} = \rho_0 \frac{du}{dt}$$

$$p = p_0\left[1 + k\sigma\right]$$

$$\frac{dp}{dx} = -p_0 k \frac{d\sigma}{dx} = \rho_0 \frac{du}{dt}$$

[illegible] 0 [illegible] $x = 0$

[illegible] $\frac{du}{dt} = 0 \quad \frac{d\sigma}{dx} = 0$

[illegible]

$x = 0$

$$\frac{d\sigma}{dx} = 0$$

[illegible]:

$$\sigma = A \sin \alpha\left[t - \frac{x\cos\lambda + y\cos\mu + z\cos\nu}{a}\right] +$$

$$+ A' \sin \alpha'\left[t - \frac{x\cos\lambda' + y\cos\mu' + z\cos\nu'}{a}\right]$$

Superpos. [illegible] 2 [illegible]

$$\frac{d\sigma}{dx} = -\frac{\alpha\cos\lambda}{a} A \cos\alpha\left[t - \frac{x\cos\lambda + y\cos\mu + z\cos\nu}{a}\right] -$$

$$- \frac{\alpha'\cos\lambda'}{a} A' \cos\alpha'\left[t - \qquad\right]$$

[illegible] $x=0$ | $\frac{d\sigma}{dx} = 0$

$$-\frac{\alpha\cos\lambda A}{a}\cos\alpha\left[t - \frac{y\cos\mu + z\cos\nu}{a}\right] - \frac{\alpha'\cos\lambda' A'}{a}\cos$$

$$\cos\alpha'\left[t - \frac{y\cos\mu' + z\cos\nu'}{a}\right] = 0$$

[illegible], $y=0$, $z=0$

[illegible] $\alpha = \alpha'$

[illegible]

$$\cos\lambda . A + \cos\lambda' . A' = 0$$

[illegible] 2 [illegible]

$$-\cos\lambda . A \cos\alpha\left(t - \frac{z\cos\nu}{a}\right) - \cos\lambda' . A' \cos\alpha\left(t - \frac{z\cos\nu'}{a}\right) = 0$$

$$\frac{\alpha\cos\nu}{a} = \frac{\alpha\cos\nu'}{a} \qquad \cos\nu = \cos\nu'$$

$$\cos\mu = \cos\mu'$$

$$\cos^2\lambda + \cos^2\mu + \cos^2\nu = 1$$

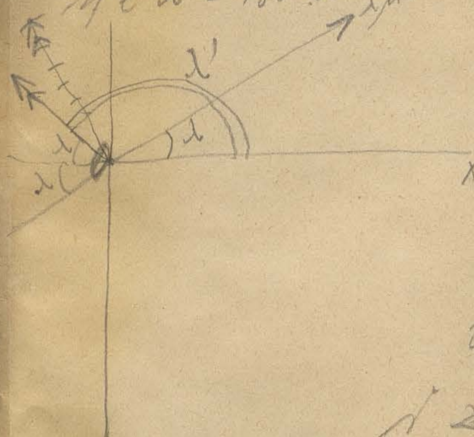
$$\cos^2\lambda' + \cos^2\mu' + \cos^2\nu' = 1$$

$$\cos^2\lambda - \cos^2\lambda' \quad = 0$$

$$\cos^2\lambda = \cos^2\lambda'$$

$\cos\lambda' = \pm\cos\lambda$ [illegible]

[illegible] $\lambda' = 180 - \lambda$



Reflexionsl [illegible]

[illegible]

$$\cos\lambda . A - \cos\lambda . A' = 0$$

$$A = A'$$ [illegible]

[illegible] Refl. [illegible] 2 Medien [illegible]

[illegible]

$$\frac{d^2\sigma}{dt^2} = a^2\left[\frac{d^2\sigma}{dx^2} + \frac{d^2\sigma}{dy^2} + \frac{d^2\sigma}{dz^2}\right] \qquad \frac{d^2\sigma_1}{dt^2} = a_1^2\left[\frac{d^2\sigma_1}{dx^2} + \ldots\right]$$

[illegible]

$x=0$:

p & σ cont. [illegible]

[illegible] ∞ cont.

$p = p_1$

$p = p_0[1+k\sigma]$ $\qquad$ $p_1 = p_0[1+k_1\sigma_1]$

$$k\sigma = k_1\sigma_1$$

[illegible]:

$u = u_1$ [illegible]

$$\frac{du}{dt} = \frac{du_1}{dt}$$

$$-p_0 k \frac{d\sigma}{dx} = \rho_0 \frac{du}{dt}$$

$$-a^2\frac{d\sigma}{dx} = \frac{du}{dt} \qquad -a_1^2\frac{d\sigma_1}{dx} = \frac{du_1}{dt}$$

$$a^2\frac{d\sigma}{dx} = a_1^2\frac{d\sigma_1}{dx}$$

17/6 Reflexion u. Brechung

$x=0$ [illegible] $\qquad k\sigma = k_1\sigma_1$

$$a^2\frac{d\sigma}{dx} = a_1\frac{d\sigma_1}{dx}$$

$\sigma = \sigma' + \sigma''$

$\sigma' = A \sin\alpha\left[t - \frac{x\cos\lambda + y\cos\mu + z\cos\nu}{a}\right]$

$$\sigma'' = A'' \sin \alpha'' \left[t - \frac{x \cos \lambda'' + y \cos \mu'' + z \cos \nu''}{a}\right]$$

$$\sigma_1 = A_1 \sin \alpha_1 \left[t - \frac{x \cos \lambda_1 + y \cos \mu_1 + z \cos \nu_1}{a_1}\right]$$

$$k A' \sin \alpha' \left[t - \frac{y \cos \mu' + z \cos \nu'}{a}\right] + k A'' \sin \alpha'' \left[t - \frac{y \cos \mu'' + z \cos \nu''}{a}\right] = k_1 A_1 \sin \alpha_1 \left[t - \frac{y \cos \mu_1 + z \cos \nu_1}{a_1}\right]$$

[illegible] $y = 0$, $z = 0$ [illegible] t [illegible]

[illegible] $\alpha' = \alpha'' = \alpha_1$ $[= \alpha]$

[illegible] Refl. [illegible]

[illegible] $t = 0$, $z = 0$ [illegible]

$$\frac{\alpha' \cos \mu'}{a} = \frac{\alpha'' \cos \mu''}{a} = \frac{\alpha_1 \cos \mu_1}{a_1}$$

$$\left.\begin{aligned} \frac{\cos \mu'}{a} &= \frac{\cos \mu''}{a} = \frac{\cos \mu_1}{a_1} \\ \frac{\cos \nu'}{a} &= \frac{\cos \nu''}{a} = \frac{\cos \nu_1}{a_1} \end{aligned}\right\} \quad \begin{aligned} \cos \mu' &= \cos \mu'' \\ \cos \nu' &= \cos \nu'' \end{aligned}$$

$$\cos^2 \mu' + \cos^2 \nu' = \cos^2 \mu'' + \cos^2 \nu''$$

$$1 - \cos^2 \lambda' = 1 - \cos^2 \lambda''$$

$$\cos^2 \lambda' = \cos^2 \lambda''$$

$$\cos \lambda' = + \cos \lambda''$$

$\cos \lambda' = - \cos \lambda''$ [illegible] Refl. [illegible] Refl.

[illegible]

$$\frac{\cos\mu'}{a} = \frac{\cos\mu_1}{a_1}$$

$$\frac{\cos\nu'}{a} = \frac{\cos\nu_1}{a_1}$$

$$\frac{\cos^2\mu' + \cos^2\nu'}{a^2} = \frac{\cos^2\mu_1 + \cos^2\nu_1}{a_1^2}$$

$$\frac{1-\cos^2\lambda'}{a^2} = \frac{1-\cos^2\lambda_1}{a_1^2}$$

$$\frac{\sin^2\lambda'}{a^2} = \frac{\sin^2\lambda_1}{a_1}$$

$$\frac{\sin^2\lambda'}{\sin^2\lambda_1} = \frac{a^2}{a_1^2}$$

[illegible]

$$\frac{\sin\lambda'}{\sin\lambda_1} = \frac{a}{a_1}$$

[illegible]

[illegible]

$\mu' = 90^0$ [illegible]

[illegible] $kA' + kA'' = k_1 A_1$ I.)

$$\frac{a^2 d\sigma}{dx} = a_1^2 \frac{d\sigma_1}{dx}$$

$$a^2\left[A'\alpha'\frac{\cos\lambda'}{a}\cos\alpha'[t-]\right] + a^2 A''\alpha''\frac{\cos\lambda''}{a}\cos\alpha'[t-] =$$

$$= a_1^2 A_1\alpha_1\frac{\cos\lambda_1}{a_1}\cos\alpha_1[t-]$$

$$a A'\cos\lambda' + a A''\cos\lambda'' = a_1 A_1\cos\lambda_1$$

$$a A'\cos\lambda' - a A''\cos\lambda' = a_1 A_1\cos\lambda_1$$

$$\frac{a}{a_1}\cos\lambda'[A'-A''] = A_1\cos\lambda_1$$

$$\frac{\sin\lambda'}{\sin\lambda_1}\cos\lambda'[A'-A''] = A_1\cos\lambda_1$$

2 K el.

9448

43

2.
Dr. Josef Stefan IV S. 92.

Akustik.

M Smoluchowski

II). $\sin\lambda'\cos\lambda'\,[A'-A''] = \sin\lambda_1\cos\lambda_1\, A_1$

[illegible] A'' [illegible] A_1 [illegible]

$$\left.\begin{array}{l} \text{I} \quad \sin\lambda_1\cos\lambda_1 \\ -\text{II} \quad k_1 \end{array}\right|$$

$$k A'\sin\lambda_1\cos\lambda_1 + k A''\sin\lambda_1\cos\lambda_1 - k_1 A'\sin\lambda'\cos\lambda' + k_1 A''\sin\lambda'\cos\lambda' = 0$$

$$A''\left[k\sin\lambda_1\cos\lambda_1 + k_1\sin\lambda'\cos\lambda'\right] = A'\left[k_1\sin\lambda'\cos\lambda' - k\sin\lambda_1\cos\lambda_1\right]$$

$$\frac{A''}{A'} = \frac{k_1\sin\lambda'\cos\lambda' - k\sin\lambda_1\cos\lambda_1}{k_1\sin\lambda'\cos\lambda' + k\sin\lambda_1\cos\lambda_1}$$

[illegible] k [illegible] $6 : k$

[illegible] temp. coll.

[illegible]

[illegible]

$$\frac{A''}{A'_*} = \frac{\sin\lambda'\cos\lambda' - \sin\lambda_1\cos\lambda_1}{\sin\lambda'\cos\lambda' + \sin\lambda_1\cos\lambda_1} =$$

[illegible] compl.

[illegible] Sigm. [illegible]

[illegible]

21/6 A' [illegible] A_1 [illegible]

A'' refl.

$$k[A'+A''] = k_1 A_1$$

$$a \cos\lambda (A'-A'') = a_1 \cos\lambda_1 A_1$$

$$\frac{a}{a_1} = \frac{\sin\lambda}{\sin\lambda_1}$$

$$\sin\lambda_1 \cos\lambda \, (A'-A'') = \sin\lambda_1 \cos\lambda_1 A_1$$

$$\frac{(k \sin\lambda_1 \cos\lambda_1 - k_1 \sin\lambda \cos\lambda) A'}{A''} =$$

[illegible] $k = k_1$

$$\frac{A''}{A'} = \frac{\sin\lambda\cos\lambda - \sin\lambda_1\cos\lambda_1}{\sin\lambda\cos\lambda + \sin\lambda_1\cos\lambda_1} = \frac{\sin 2\lambda - \sin 2\lambda_1}{\sin 2\lambda + \sin 2\lambda_1}$$

$$= \frac{\sin(\lambda-\lambda_1)\cos(\lambda+\lambda_1)}{\sin(\lambda+\lambda_1)\cos(\lambda-\lambda_1)} = \frac{tg(\lambda-\lambda_1)}{tg(\lambda+\lambda_1)}$$

[illegible] Fresnel, Intens. [illegible] refl. [illegible]

[illegible] λ [illegible] $= 0$

[illegible] $\lambda + \lambda_1 = 90$

$$\lambda_1 = 90 - \lambda$$

$$\sin\lambda_1 = \cos\lambda$$

$$\frac{\sin\lambda}{\sin\lambda_1} = \frac{a}{a_1} = n \qquad tg\,\lambda = n \quad [illegible]$$

[illegible] Med. [illegible] s. [illegible]

[illegible] refl.

$k = k_1$ [illegible] 20. [illegible] 0,5 H; [illegible] 4 : 4 [illegible]

experimentell [illegible]

[illegible] Optik [illegible] $\perp$ [illegible] Polar.

[illegible]

$$a^2 = \frac{\mu_0 k}{\rho_0} \qquad a_1^2 = \frac{\mu_0 k_1}{\rho_0}$$

$$k : k_1 = a^2 : a_1^2$$

$$= \sin^2\lambda : \sin^2\lambda_1$$

$$\frac{A''}{A'} = -\frac{\sin^2\lambda \sin\lambda_1 \cos\lambda_1 - \sin^2\lambda_1 \sin\lambda \cos\lambda}{\sin^2\lambda \sin\lambda_1 \cos\lambda_1 + \sin^2\lambda_1 \sin\lambda \cos\lambda}$$

$$= \frac{~~\sin\lambda \sin\lambda_1~~ [\sin\lambda \cos\lambda_1 - \sin\lambda_1 \cos\lambda]}{\sin\lambda \cos\lambda_1 + \sin\lambda_1 \cos\lambda}$$

$$= -\frac{\sin(\lambda - \lambda_1)}{\sin(\lambda + \lambda_1)}$$

[illegible] Fresnel, [illegible] $\perp$ [illegible]

[illegible] Fresnel'sche [illegible]

Transversalschwingungen elastischer Stäbe.

[illegible] [illegible]



[illegible] Bernoulli [illegible] Euler [illegible]

[illegible] = Elast [illegible]

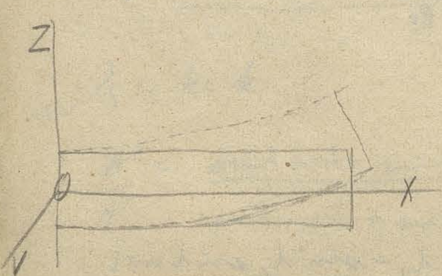
[illegible] Settham [illegible]

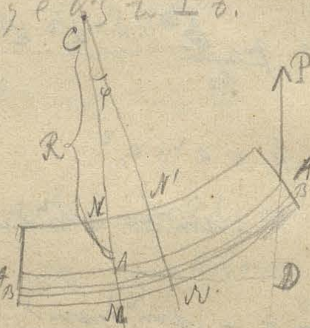
[illegible]

[illegible]

[illegible] Parallel [illegible] Neutrale [illegible]

Euler [illegible] ⊥ [illegible]





$MN \perp$

$C =$ [illegible] C.

AA' [illegible]

$\omega =$ [illegible] BB'

$\omega\, \mathfrak{E} \dfrac{(BB' - AA')}{AA'} =$ [illegible] $= p$

$AA' = R\varphi$

$BB' = (R + AB)\varphi$

$AB = \xi$

$BB' = R\varphi + \xi\varphi \;\big|\; p = \omega\, \mathfrak{E}\, \dfrac{\xi}{R}$

[illegible] W [illegible]

[illegible] $\parallel X$ [illegible] Resultl. $= 0$ [illegible]

$\sum (p \cos\alpha) = 0 \qquad \sum \omega\, \mathfrak{E} \dfrac{\xi}{R} \cos\alpha = 0 \;\Big|\; \dfrac{\mathfrak{E}}{R} \sum \omega \xi \cos\alpha = 0$

[illegible] neutr. [illegible]

22/6

$p = w \frac{l\,y}{R}$



[illegible] A [illegible]

[illegible] $\Sigma = 0$ [illegible]

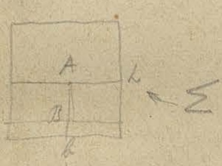
[illegible] A [illegible]

$p\,AB = w\,\frac{l\,\overline{AB}^2}{R}$

$\Sigma\, p\, AB = \frac{l}{R} \underbrace{\Sigma\, w\, \overline{AB}^2}$

[illegible]

[illegible] $= K$



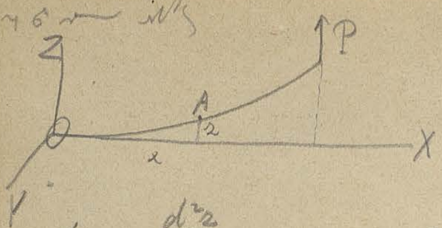
$\Sigma\, p\, \overline{AB} = \frac{lK}{R}$ [illegible]

[illegible] $\frac{lK}{R}$

[illegible]

[illegible]

$P.\,\overline{AD}$ $\qquad \frac{lK}{R} = P.\,\overline{AD}.$



$$\frac{1}{r} = \frac{\frac{d^2z}{dx^2}}{\left[1+\left(\frac{dz}{dx}\right)^2\right]^{\frac{3}{2}}}$$ [illegible] conv. [illegible] conc. [illegible]

$$= \text{proxime } \frac{d^2z}{dx^2}$$

$AD = l - x$ [illegible]

$$EK\frac{d^2z}{dx^2} = P(l-x)$$

$$EK\frac{dz}{dx} = P\left(lx - \frac{x^2}{2}\right) + C$$

$$EKz = P\left(l\frac{x^2}{2} - \frac{x^3}{6}\right) + Cx + D$$

$x=0 \quad z=0 \qquad D=0$

[illegible]

$x=0 \quad \frac{dz}{dx}=0 \qquad C=0$

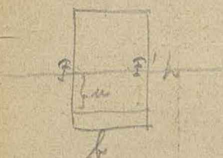
$$z = \frac{P}{EK}\left(l\frac{x^2}{2} - \frac{x^3}{6}\right)$$

$z_1 =$ [illegible] $= ?$

[illegible]

$$z_1 = \frac{P}{EK}\left(\frac{l^3}{2} - \frac{l^3}{6}\right) = \frac{1}{3}\,\frac{Pl^3}{EK}$$ [illegible]

[illegible]



$$K = \int_{-\frac{h}{2}}^{+\frac{h}{2}} u^2 b \, du = \frac{bu^3}{3}\Bigg|_{-\frac{h}{2}}^{\frac{h}{2}} = \frac{bh^3}{12}$$

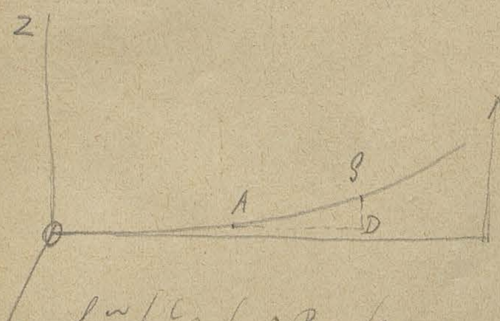
$$z_1 = \frac{12}{3}\frac{Pl^3}{E\,bh^3} = \frac{4Pl^3}{Ebh^3}$$ [illegible]

" " [illegible] 3 [illegible]

[illegible] 3 [illegible]



[illegible]



$$\frac{EK}{R}$$

[illegible]

[illegible]

[illegible]

$$\frac{EK}{R} = g\,\overline{AD} = q\rho(l-x)g\,\frac{l-x}{2}$$

$$\varrho K \frac{d^2 z}{dx^2} = \frac{q\rho g}{2}(l-x)^2$$

$$\varrho K \frac{dz}{dx} = \frac{q\rho g}{2}\left(l^2 x - l x^2 + \frac{x^3}{3}\right) + C$$

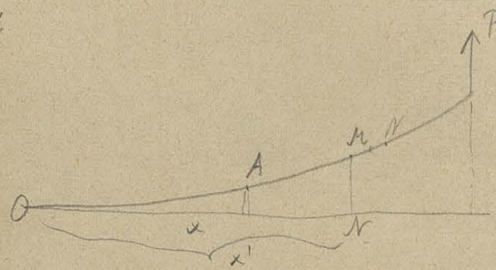
$$\varrho K z = \frac{q\rho g}{2}\left[l^2\frac{x^2}{2} - l\frac{x^3}{3} + \frac{x^4}{12}\right] + Cx + D$$

$$z = \frac{q\rho g}{2\varrho K}\left[\frac{l^2x^2}{2} - \frac{lx^3}{3} + \frac{x^4}{12}\right]$$

$x = l$

$$z_1 = \frac{q\rho g}{2\varrho K}\left[\frac{l^4}{2} - \frac{l^4}{3} + \frac{l^4}{12}\right] = \overbrace{\frac{q\rho g\, l}{8\varrho K}}^{1' \text{ об } l} \cdot l^3$$

23/6



1) $1/l$ [illegible]

2) [illegible]

$\rho q\, MNZ'$

$$\frac{\varrho K}{R} - P(l-x) - \sum \rho q\, MN\, z'(x-x') \qquad MN = dx'$$

$$1)\ \varrho K \frac{d^2 z}{dx^2} - P(l-x) - \rho q \int_{x'=x}^{x'=l} Z'(x'-x)\, dx' = 0$$

$$2)\ \varrho K \frac{d^3 z}{dx^3} + P + \rho q \int_x^l Z'\, dx' + \rho q\, Z'(x'-x) = 0$$

$$I = \int_x^l f(x')\, dx'$$

$$\frac{dI}{dx} = -f(x)$$

2) $\mathcal{E} K \frac{d^3 z}{dx^3} + P + \rho q \int_x^l z' dx' = 0$ $\qquad z'\Big|_{x'=x} = z$ 49

3) $\mathcal{E} K \frac{d^4 z}{dx^4} - \rho q z = 0$

np. gr $z = g$

$$\mathcal{E} K \frac{d^4 z}{dx^4} = \rho q g$$

$$\mathcal{E} K \frac{d^3 z}{dx^3} = \rho q g x + C$$

$$\mathcal{E} K \frac{d^2 z}{dx^2} = \rho q g \frac{x^2}{2} + C x + D$$

$$\mathcal{E} K \frac{dz}{dx} = \rho q g \frac{x^3}{6} + C \frac{x^2}{2} + D x + \mathcal{E}$$

$$\mathcal{E} K z = \rho q g \frac{x^4}{24} + C \frac{x^3}{6} + D \frac{x^2}{2} + \mathcal{E} x + F$$

$x = 0 \,|\, z = 0 \quad \frac{dz}{dx} = 0$

$F = 0 \quad \mathcal{E} = 0$

$x = l$ 1). $\mathcal{E} K \frac{d^2 z}{dx^2} = 0$

2). $\mathcal{E} K \frac{d^3 z}{dx^3} + P = 0$

$\omega P = 0 \,|\, x = l \,|$ $\quad \mathcal{E} K \frac{d^3 z}{dx^3} = 0$ $\quad$ ~~$\mathcal{E} K \frac{d^2 z}{dx^3} = 0$~~

[illegible]

$0 = \rho q g l + C \qquad C = -\rho q g l$

$0 = \rho q g \frac{l^2}{2} + C l + D \qquad D = +\rho q g \frac{l^2}{2}$

$$qKz = \rho q g \left[\frac{x^4}{24} - \frac{l x^3}{6} + \frac{l^2 x^2}{4}\right]$$

$x = l$

$$qKz_1 = \rho q g \frac{l^4}{8} = p g \frac{l^3}{8} \quad \text{[illegible]}$$

---

3). $$qK \frac{d^4 z}{dx^4} - \rho q Z = 0$$ [illegible] d'Alembert [illegible]

$$qK \frac{d^4 z}{dx^4} - \rho q \left[Z - \frac{d^2 z}{dt^2}\right] = 0$$

[illegible] $$\rho q Z - qK \frac{d^4 z}{dx^4} = 0$$

$$\rho q\, dx\, Z - qK \frac{d^4 z}{dx^4} dx = 0$$

[illegible] [illegible]

$$= \rho q\, dx \frac{d^2 z}{dt^2}$$

[illegible]

$$\rho q Z - qK \frac{d^4 z}{dx^4} = \rho q \frac{d^2 z}{dt^2}$$ [illegible] : $Z = 0$

$$+ qK \frac{d^4 z}{dx^4} + \rho q \frac{d^2 z}{dt^2} = 0 \qquad \frac{qK}{\rho q} = a^2$$

$$a^2 \frac{d^4 z}{dx^4} = - \frac{d^2 z}{dt^2}$$

$$\frac{d^2 z}{dt^2} + a^2 \frac{d^4 z}{dx^4} = 0$$ [illegible]

$z = U \sin \alpha t$ $\quad$ $U \cos \alpha x$

$$\frac{d^2 z}{dt^2} = -\alpha^2 U \sin \alpha t \qquad \frac{d^4 z}{dx^4} = \frac{d^4 U}{dx^4} \sin \alpha t$$

$$-\alpha^2 U \sin \alpha t + a^2 \frac{d^4 U}{dx^4} \sin \alpha t = 0$$

$$U = e^{\gamma x}$$

$$-\alpha^2 e^{\gamma x} + a^2 \gamma^4 e^{\gamma x} = 0$$

$$\gamma^4 = \frac{\alpha^2}{a^2} \qquad \gamma^2 = \pm \frac{\alpha}{a}$$

$$\gamma = \pm \sqrt{\pm \frac{\alpha}{a}}$$

8 2

24/6

$$\frac{d^2 z}{dt^2} + a^2 \frac{d^4 z}{dx^4} = 0$$

$$z = U \sin \alpha t$$

$$-\alpha^2 U + a^2 \frac{d^4 U}{dx^4} = 0 \qquad U = e^{\gamma x}$$

$$\gamma^4 = \frac{\alpha^2}{a^2} \qquad \frac{\alpha^2}{a^2} = b^4$$

$$\gamma^4 = b^4$$

$$\gamma = \pm b, \pm bi$$

$$U = M_1 e^{bx} + M_2 e^{-bx} + M_3 e^{bxi} + M_4 e^{-bxi}$$

Dopo $z = U \sin \alpha t$

$$U = A \frac{e^{bx} + e^{-bx}}{2} + B \frac{e^{bx} - e^{-bx}}{2} + C \cos bx + D \sin bx$$

2B. l − x [illegible]

$x=0$	$x=l$	$x=0$	$x=l$
$\xi=0$	$\frac{d^2\xi}{dx^2}=0$	$U=0$	$\frac{d^2U}{dx^2}=0$
$\frac{d\xi}{dx}=0$	$\frac{d^3\xi}{dx^3}=0$	$\frac{dU}{dx}=0$	$\frac{d^3U}{dx^3}=0$

$$\frac{dU}{dx}=b\left[A\frac{e^{bx}-e^{-bx}}{2}+B\frac{e^{bx}+e^{-bx}}{2}-C\sin bx+D\cos bx\right]$$

$$\frac{d^2U}{dx^2}=b^2\left[A\frac{e^{bx}+e^{-bx}}{2}+B\frac{e^{bx}-e^{-bx}}{2}-C\cos bx-D\sin bx\right]$$

$$\frac{d^3U}{dx^3}=b^3\left[A\frac{e^{bx}-e^{-bx}}{2}+B\frac{e^{bx}+e^{-bx}}{2}+C\sin bx-D\cos bx\right]$$

$$0=A+C$$

$$0=b[B+D]$$

$$0=A\frac{e^{bl}+e^{-bl}}{2}+B\frac{e^{bl}-e^{-bl}}{2}-C\cos bl-D\sin bl$$

$$0=A\frac{e^{bl}-e^{-bl}}{2}+B\frac{e^{bl}+e^{-bl}}{2}+C\sin bl-D\cos bl$$

[illegible]

$$0=A\left[\frac{e^{bl}+e^{-bl}}{2}+\cos bl\right]+B\left[\frac{e^{bl}-e^{-bl}}{2}+\sin bl\right]$$

$$0=A\left[\frac{e^{bl}-e^{-bl}}{2}-\sin bl\right]+B\left[\frac{e^{bl}+e^{-bl}}{2}+\cos bl\right]$$

$z = A_1 u_1 \sin\alpha_1 t + A_2 u_2 \sin\alpha_2 t + \ldots$

[illegible] $u \cos\alpha t$ [illegible]

$+ F_1 u_1 \cos\alpha_1 t + F_2 u_2 \cos\alpha_2 t + \ldots$

[illegible]

[illegible]

$\int_0^l u_h u_k \, dx = 0$ [illegible]

[illegible]

$h — 1$
$k — 2$

$\int_0^l u_1 u_2 \, dx$ $\qquad \frac{d^4 u_1}{dx^4} = -b_1^4 u_1$

$\frac{d^4 u_2}{dx^4} = -b_2^4 u_2$

$$b_1^4 \int_0^l u_1 u_2 \, dx = -\int_0^l u_2 \frac{d^4 u_1}{dx^4} dx = -u_2 \frac{d^3 u_1}{dx^3} + \int_0^l \frac{du_2}{dx} \frac{d^3 u_1}{dx^3} dx$$

$$= -u_2 \frac{d^3 u_1}{dx^3} + \frac{du_2}{dx} \frac{d^2 u_1}{dx^2} - \int \frac{d^2 u_2}{dx^2} \frac{d^2 u_1}{dx^2} dx$$

$$= -u_2 \frac{d^3 u_1}{dx^3} + \frac{du_2}{dx} \frac{d^2 u_1}{dx^2} - \frac{d^2 u_2}{dx^2} \frac{du_1}{dx} + \int \frac{d^3 u_2}{dx^3} \frac{du_1}{dx} dx$$

$$= -u_2 \, d - \qquad\qquad + \frac{d^3 u_2}{dx^3} u_1 - \underbrace{\int \frac{d^4 u_2}{dx^4} u_1 \, dx}_{+ b_2^4 \int u_2 u_1 \, dx}$$

$$(b_1^4 - b_2^4) \int_0^l u_1 u_2 \, dx = \left[-u_2 \frac{d^3 u_1}{dx^3} + \frac{du_2}{dx} \frac{d^2 u_1}{dx^2} - \frac{d^2 u_2}{dx^2} \frac{du_1}{dx} + \frac{d^3 u_2}{dx^3} u_1 \right]_0^l$$

[illegible]

$x = l$

$$\frac{d^2u}{dx^2} = \frac{d^3u}{dx^3} = 0$$

$$\frac{d^2u_1}{dx^2} = \frac{d^3u_1}{dx^3} = 0 \qquad \frac{d^2u_2}{dx^2} = \frac{d^3u_2}{dx^3} = 0$$

[illegible]

$x = 0 \qquad u = 0$

$$\frac{du}{dx} = 0$$

[illegible]

[illegible]

$$(b_1^4 - b_2^4)\int_0^l u_1 u_2 \, dx = 0$$

[illegible] $b_1 \neq b_2$ [illegible] $\int = 0$ [illegible]

$$\int_0^l u_1 u_2 \, dx = 0$$

[illegible] $\int 1 = 0$ [illegible]

$$z = A_1 u_1 \sin \alpha_1 t + A_2 u_2 \sin \alpha_2 t + \text{---}$$

$$+ F_1 u_1 \cos \alpha_1 t + F_2 u_2 \cos \alpha_2 t + \text{---}$$

$$\frac{dz}{dt} = \alpha_1 A_1 u_1 \cos \alpha_1 t + \text{---}$$

$$- \alpha_1 F_1 u_1 \sin \alpha_1 t + \text{---}$$

$t = 0 \quad z = \varphi(x)$

$$\frac{dz}{dt} = \psi(x)$$

$\varphi(x) = F_1 u_1 + F_2 u_2 + \cdots$

$\frac{dz}{dt} = \psi(x) = \alpha_1 A_1 u_1 + \alpha_2 A_2 u_2 + \cdots$

$\int_0^l \varphi(x)\,dx \cdot u_1 = F_1 \int_0^l u_1^2\,dx + \underbrace{F_2 \int_0^l u_1 u_2\,dx + F_3 \int_0^l u_1 u_3\,dx + \cdots}_{=0}$

[illegible] F_1

[illegible] A_1

[illegible] $\varphi(x)$ [illegible] $\psi(x)$ [illegible]

[illegible] $\varphi(x)$, $x=0$ $=0$ [illegible]

[illegible]

[illegible] $=\Sigma$ [illegible]

[illegible]

5/7 $\frac{d^2 z}{dt^2} + a^2 \frac{d^4 z}{dx^4} = 0 \qquad a^2 = \frac{gK}{q\rho}$

[illegible] l [illegible]

$z = A \sin\alpha\left(t - \frac{x}{c}\right) \qquad c =$ [illegible]

[illegible]

$\frac{dz}{dt} = \alpha A \cos\alpha\left(t - \frac{x}{c}\right) \qquad \frac{d^2 z}{dt^2} = -\alpha^2 A \sin\alpha\left(t - \frac{x}{c}\right)$

$$\frac{dz}{dx} = -\frac{\alpha}{c} A \cos \alpha\left(t - \frac{x}{c}\right)$$

$$\frac{d^2 z}{dx^2} = -\frac{\alpha^2}{c^2} A \sin \alpha\left(t - \frac{x}{c}\right)$$

$$\frac{d^3 z}{dx^3} = \frac{\alpha^3}{c^3} A \cos \alpha\left(t - \frac{x}{c}\right)$$

$$\frac{d^4 z}{dx^4} = \frac{\alpha^4}{c^4} A \sin \alpha\left(t - \frac{x}{c}\right)$$

$$-\alpha^2 A \sin \alpha\left(t - \frac{x}{c}\right) + a^2 \frac{\alpha^4}{c^4} A \sin \alpha\left(t - \frac{x}{c}\right) = 0$$

$$-\alpha^2 + \frac{a^2 \alpha^4}{c^4} = 0$$

$$c^4 = a^2 \alpha^2$$ [illegible]

$$c = \sqrt{a\alpha}$$

$$\alpha = \frac{2\pi}{\tau}$$ [illegible]

$$c\tau = \lambda$$

$$\alpha = \frac{2\pi}{\lambda} c$$

$$c^4 = a^2 \frac{4\pi^2}{\lambda^2} c^2$$

$$c^2 = \frac{a^2 4\pi^2}{\lambda^2}$$

$$c = a \frac{2\pi}{\lambda}$$ [illegible]

[illegible]

[illegible]

[illegible] Dispersion; [illegible]

[illegible]

[illegible] $f(t)$ [illegible]

[illegible] $f(t - \frac{x}{a})$ [illegible] $f(t)$ [illegible] per[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

$$\frac{q\varrho}{\mu}\,\frac{d^2\xi}{dt^2} = P\,\frac{d^2\xi}{dx^2} - \varrho K\,\frac{d^4\xi}{dx^4}$$

$$\frac{d^2\xi}{dt^2} = \frac{P}{\mu}\,\frac{d^2\xi}{dx^2} - \frac{\varrho K}{\rho q}\,\frac{d^4\xi}{dx^4}$$

$\xi = A \sin\alpha t \sin\beta x$ $\quad x = l$

$\xi = 0$ $\quad \sin\beta l = 0$

$$-\alpha^2 = \frac{-P}{\mu}\beta^2 - \frac{\varrho K}{\mu}\beta^4$$

$$\alpha^2 = \beta^2 \frac{P}{\mu} + \frac{QK}{\mu} \beta^4$$

m. $\beta l = \pi$ [illegible]

$$\beta = \frac{\pi}{l}$$

$$\alpha^2 = \frac{\pi^2}{l^2} \frac{P}{\mu} + \frac{\pi^4}{l^4} \frac{QK}{\mu} \qquad \alpha = 2n\pi$$

$$4n^2\pi^2 = \overline{\qquad\qquad}$$

$$n^2 = \frac{1}{4l^2} \frac{P}{\mu} + \frac{\pi^2}{4l^4} \frac{QK}{\mu}$$

$$n = \frac{1}{2l} \sqrt{\frac{P}{\mu}} \sqrt{1 + \frac{\pi^2}{l^2} \frac{QK}{P}}$$ [illegible]

[illegible] Corr. [illegible]

[illegible] $n >$ [illegible]

[illegible] 2 [illegible]

[illegible] l^2 [illegible] $\frac{l^2}{4}$; [illegible] Corr. [illegible]

[illegible] Octave [illegible] Harm.

[illegible]

[illegible] long [illegible]

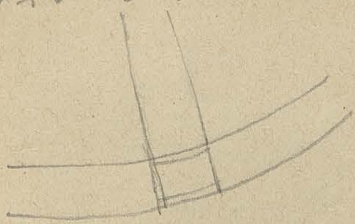
[illegible] etc.

[illegible]

[illegible]

[illegible]

[illegible]



[illegible]

[illegible]

[illegible] transv. [illegible]

[illegible] [transv.]

[illegible] Vol. contr. [illegible]. : Quer-Contraction.

[illegible]

z.B.



$\lambda = a$ | [illegible]: a'

$$q\,\mathfrak{E}\,\frac{a'-a}{a} = P$$

$$\frac{a'-a}{a} = \frac{1}{q\mathfrak{E}}\,P$$

$$b' = b(1-\beta\alpha) \qquad a' = a\left[1+\frac{1}{q\mathfrak{E}}P\right]$$

$$c' = c(1-\beta\alpha) \qquad = a\left[1+\alpha\right]$$

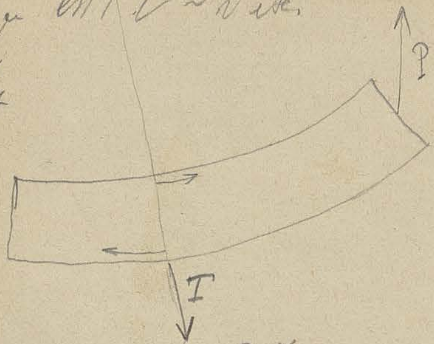
Vol. $a'b'c' = abc\left[(1+\alpha)(1-\beta\alpha)(1-\beta\alpha)\right]$

$$= abc\left[1+\alpha-2\beta\alpha\right]$$ [illegible] Vol. [illegible] $\alpha\,2\beta$

[illegible] $2\rho = 1$ [illegible] Kautschouk

[illegible]

6/7



[illegible]

$M =$ [illegible] $= \frac{EK}{R}$

[illegible] $\frac{EK}{R} = P(l-x)$

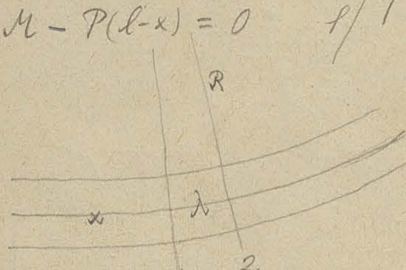
[illegible]

[illegible]

P [illegible]

[illegible] $T = P$; [illegible] $= P(l-x)$

$M - P(l-x) = 0$ [illegible]



[illegible]

Σ [illegible] $= 0$ $X = 0$ $Z = 0$

Σ [illegible] $= 0$

[illegible]

1). [illegible] M [illegible]

2). — M' [illegible]

1). T [illegible]

2). T' [illegible]

[illegible] Z [illegible]

Z [illegible]

[illegible]

$$-T + T' + \rho q \lambda z = 0$$

$$M - M' - T\lambda = 0$$

$$T = \varphi(x) \qquad T' = \varphi(x+\lambda) = \varphi(x) + \lambda \frac{\partial \varphi(x)}{\partial x} + \cdots$$

$$= T + \lambda \frac{dT}{dx}$$

$$M = \varphi(x) \qquad M' = \varphi(x+\lambda) = M + \lambda \frac{dM}{dx}$$

$$\lambda \frac{dT}{dx} + \rho q \lambda z = 0 \qquad\qquad -\lambda \frac{dM}{dx} - \lambda T = 0$$

$$\frac{dT}{dx} + \rho q z = 0 \qquad\qquad \frac{dM}{dx} + T = 0$$

$$-\frac{d^2M}{dx^2} + \rho q z = 0 \qquad\qquad \frac{d^2M}{dx^2} + \frac{dT}{dx} = 0$$

$$-\varepsilon K \frac{d^2}{dx^2}\left(\frac{1}{R}\right) + \rho q z = 0$$

$$\frac{1}{R} = \frac{d^2 z}{dx^2}$$

$$-\varepsilon K \frac{d^4 z}{dx^4} + \rho q z = 0$$ [illegible]

$$-\varepsilon K \lambda \frac{d^4 z}{dx^4} + \rho q \lambda z = 0$$ [illegible]

[illegible]

$$-\varepsilon K \lambda \frac{d^4 z}{dx^4} + \rho q \lambda z = \rho q \lambda \frac{d^2 z}{dt^2}$$

[illegible]

[illegible]: $-\frac{dM}{dx}\lambda - T\lambda = 0$

[illegible]

[illegible]

[illegible] Σ [illegible] = [illegible] $\times$ [illegible]

[illegible] = [illegible] λ^2 [illegible]

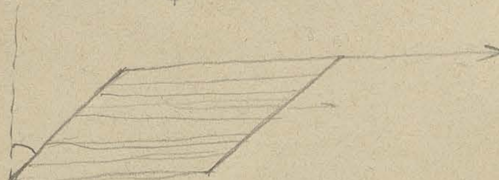
[illegible]

[illegible] Normal-Sp. ; [illegible] Tangential-Sp.

[illegible]



[illegible]

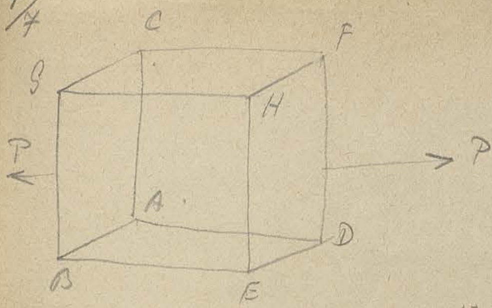


[illegible]

scherende [illegible]

Scherungs-Sp.

7/7



~~AD~~ $\sqrt{\delta} = A'D'$

relat. [illegible]: $\frac{A'D' - AD}{AD} \cdot E$.

$\cdot [ABCG] = P$

$$\frac{A'D' - AD}{AD} = \frac{P}{E[ABCG]}$$

$p_1 =$ [illegible]

[illegible] ABC [illegible]

Ac

[illegible]

[illegible] p_2

[illegible]

$$\xi_1 = \frac{1}{E} \times p_1$$

$$\eta_1 = -\beta\, \xi_1$$

$$\zeta_1 = -\beta\, \xi_1$$

$$\eta_2 = \frac{p_2}{E}$$

$$\xi_2 = -\beta\, \eta_2$$

$$\zeta_2 = -\beta\, \eta_2$$

$$\xi_3 = \frac{p_3}{E}$$

$$\xi_3 = -\beta\, \xi_3$$

$$\zeta_3 = -\beta\, \xi_3$$

[illegible]

$$\xi_1 + \xi_2 + \xi_3 = \xi = \frac{1}{E} p_1 - \beta \frac{p_2}{E} - \beta \frac{p_3}{E}$$

$$= \frac{p_1 - \beta(p_2 + p_3)}{E}$$

[illegible]

$$\eta = \frac{p_2 - \beta(p_3 + p_1)}{E}$$

$$\zeta = \frac{p_3 - \beta(p_1 + p_2)}{E}$$

$$\xi + \eta + \zeta = \frac{(1-2\beta)(p_1 + p_2 + p_3)}{E}$$

$$A'D' = AD(1+\xi)$$

$$A'B' = AB(1+\eta)$$

$$A'C' = AC(1+\zeta)$$

$$\overline{A'D'} \cdot \overline{A'B'} \cdot \overline{A'C'} = AD \cdot AB \cdot AC (1+\xi)(1+\eta)(1+\zeta)$$

$$v' = v(1+\xi)(1+\eta)(1+\zeta) = v(1+\xi+\eta+\zeta)$$

$$\frac{v'-v}{v} = \xi+\eta+\zeta = \frac{(1-2\beta)(p_1+p_2+p_3)}{E}$$

Vol. [illegible] const. [illegible] [Vol. [illegible]]

[illegible]

$p_1 = p_2 = p_3 = p$

Volumm. Elast.

$$\frac{v'-v}{v} = \left[\frac{3(1-2\beta)}{E}\right] p \quad \text{[illegible]}$$

$\frac{E}{3(1-2\beta)}$ = Elast. [illegible] Vol.

[illegible] $\beta = \frac{1}{2}$ [illegible] Vol. [illegible] $= 0$ [illegible] incompr.

[illegible] compr. [illegible] $\beta < \frac{1}{2}$

[illegible] $\frac{1}{4}$ [illegible] $\frac{1}{3}$

[illegible] Contr. [illegible] compress[illegible]
[illegible] Piezometer [illegible] Oersted

$$\xi = \frac{p_1 - \beta(p_2 + p_3)}{E} \qquad \eta = \frac{p_2 - \beta(p_3 + p_1)}{E} \qquad \zeta = \frac{p_3 - \beta(p_1 + p_2)}{E}$$

[illegible] $p_1\, p_2\, p_3$ [illegible] ξ, η, ζ.

$$\xi = \frac{p_1(1+\beta) - \beta(p_1 + p_2 + p_3)}{E}$$

$$p_1 + p_2 + p_3 = \frac{E}{1-2\beta}(\xi + \eta + \zeta)$$

$$E\xi = p_1(1+\beta) - \frac{\beta E}{1-2\beta}(\xi + \eta + \zeta)$$

$$p_1(1+\beta) = E\xi + \frac{\beta E}{1-2\beta}(\xi + \eta + \zeta)$$

$$p_1 = \frac{E}{1+\beta}\left[\xi + \frac{\beta}{1-2\beta}(\xi + \eta + \zeta)\right]$$

$$= \frac{E}{(1+\beta)(1-2\beta)}\left[(1-\beta)\xi + \beta\eta + \beta\zeta\right]$$

$$p_2 = \frac{E}{(1+\beta)(1-2\beta)}\left[(1-\beta)\eta + \beta\zeta + \beta\xi\right]$$

$p_3 =$

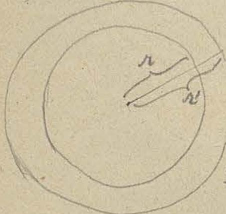
8/7 Deformation einer Kugelschale [illegible]

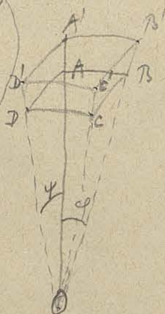
[illegible]

[illegible] Rad.

[illegible]

[illegible]





[illegible]

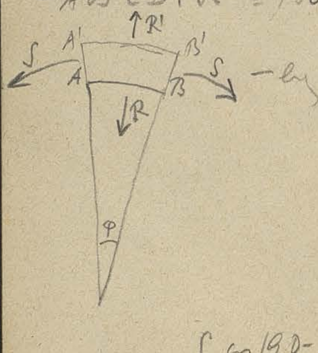
[illegible] Rad.

R' = [illegible]

R = [illegible]

A'B'C'D'. R' = [illegible]

−ABCD. R = ~~[illegible]~~ [illegible]



− [illegible]   [illegible]

ADD'A'. S

[illegible] R [illegible] Compon. [illegible] R [illegible]

$$S \cos(90 - \tfrac{\varphi}{2}) = S \sin \tfrac{\varphi}{2} = S \tfrac{\varphi}{2}$$

$-ADD'A' . S . \frac{\varphi}{2}$

$-DCC'D' . S . \frac{\varphi}{2}$

$(A'B'C'D')R' - (ABCD)R - (ADD'A')S_\varphi - (DCC'D')S_\psi = 0$

$ABCD = AB.AD = r^2\varphi\psi$

$A'B'C'D' = r'^2\varphi\psi$

$ADD'A' = AD.AA' = r\psi.AA'$

$ABB'A' = r\varphi.AA'$

$r'^2\varphi\psi R' - r^2\varphi\psi R - r\psi\,\overline{aa'}\,S_\varphi - r\varphi\,\overline{aa'}\,S_\psi = 0$

$$\frac{r'^2R' - r^2R}{aa'} - 2rS = 0$$

$$\frac{d(r^2R)}{dr} - 2rS = 0$$

R, S [illegible]:



$AB = u$ = [illegible]

$A'B' = u'$

$$\frac{BB' - AA'}{AA'} = \frac{A'B' - AB}{AA'} = \frac{u'-u}{AA'}$$

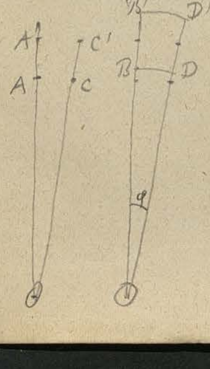
rel. [illegible]

$u = f(r)$

$u' = f(r + AA') = f(r) + AA' f'(r)$

[illegible]

$= \frac{du}{dr}$



$$\frac{B'D' - A'C'}{A'C'} = (r'+u)\varphi -$$

$$\frac{BD - AC}{AC} = \frac{(r+u)\varphi - r\varphi}{r\varphi}$$

rel. [illegible] $= \frac{u}{r}$

$$\xi = \frac{p_1 - \beta(p_2 + p_3)}{\varepsilon} \qquad \frac{du}{dr} = \frac{R - 2\beta S}{\varepsilon}$$

$$\frac{u}{r} = \frac{S - \beta(S+R)}{\varepsilon} = \frac{(1-\beta)S - \beta R}{\varepsilon}$$

[illegible] $\S\,2$ ✓ — β R S S [illegible]

[illegible]:

$$u = \frac{(1-\beta)Sr - \beta Rr}{\varepsilon}$$

$$\frac{du}{dr} = \frac{(1-\beta)\frac{d(rS)}{dr} - \beta\frac{d(Rr)}{dr}}{\varepsilon}$$

$$R - 2\beta S = (1-\beta)\frac{d(rS)}{dr} - \beta\frac{d(rR)}{dr} \qquad \text{II.}$$

$$\frac{d(r^2R)}{dr} - 2rS = 0$$

$$\frac{d(r \cdot rR)}{dr}$$

$$rR + r\frac{d(rR)}{dr} - 2rS = 0$$

$$\frac{d(rR)}{dr} = 2S - R$$

$$R - 2\beta S = (1-\beta)\frac{d(rS)}{dr} - 2\beta S + \beta R$$

$$\left.\begin{aligned} R &= \frac{d(rS)}{dr} \\ \frac{d(r^2R)}{dr} &= 2rS \end{aligned}\right\}$$

12/7

$$\frac{d(r^2R)}{dr} - 2rS = 0 \qquad \Big| \; \frac{d}{dr}$$

$$R = \frac{d(rS)}{dr}$$

$$\frac{d^2(r^2R)}{dr^2} = 2\,\frac{d(rS)}{dr} = 2R$$

$$\frac{d^2(r^2R)}{dr^2} = \frac{2}{r^2}\cdot(r^2R)$$

$$r^2R = A\,r^{n+2}$$

$$R = A\,r^n$$

$$\frac{d^2(A\,r^{n+2})}{dr^2} = 2A\,r^n$$

$$(n+2)(n+1)\,r^n = 2r^n \quad \text{[illegible]}$$

$$n^2 + 3n + 2 = 2$$

$$n = 0 \qquad n = -3$$

$$R = A + \frac{B}{r^3}$$

[illegible] Const.

[illegible]

1) [illegible]

$r = 0 \quad R = \infty$

[illegible] $B = 0$

$R = A$ [illegible] const. [illegible]

2). [illegible]

$r_0 = n \quad r_1 =$ [illegible] Rad.

$R_0 \quad R_1$

$$R_0 = A + \frac{B}{r_0^3}$$

$$R_1 = A + \frac{B}{r_1^3}$$

$$R_0 - R_1 = B\left[\frac{1}{r_0^3} - \frac{1}{r_1^3}\right] = B\,\frac{r_1^3 - r_0^3}{r_0^3 r_1^3}$$

$$R_0 r_0^3 - R_1 r_1^3 = A\left[r_0^3 - r_1^3\right]$$

$$A = \frac{R_1 r_1^3 - R_0 r_0^3}{r_1^3 - r_0^3}$$

$$B = \frac{r_0^3 r_1^3\left[R_0 - R_1\right]}{r_1^3 - r_0^3}$$

[illegible]

$$2rS = \frac{d}{dr}(r^2 R) = \frac{d}{dr}\left(Ar^2 + \frac{B}{r}\right)$$

$$= 2Ar - \frac{B}{r^2}$$

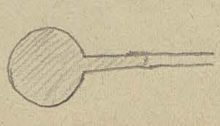
$$S = A - \frac{B}{2r^3}$$

~~$S = A - \frac{B}{2r^3}$~~

$R + 2S = \text{const.}$

[illegible]

r_0 — $r_0 + u_0$



$$\frac{u}{r} = \frac{S}{Q} - \beta\frac{S}{Q} - \beta\frac{R}{Q}$$

$$\frac{u}{r} = \frac{(1-\beta)S - \beta R}{Q}$$

$$\frac{u}{r} = \frac{(1-\beta)\,A - \frac{1-\beta}{2}\frac{B}{r^3} - \beta A - \beta\frac{B}{r^3}}{E}$$

$$= \frac{(1-2\beta)A - \sout{\ldots} - \frac{1}{2}(1+\beta)\frac{B}{r^3}}{E}$$

Voll r. $B=0$

$$\frac{u}{r} = (1-2\beta)\frac{A}{E} = (1-2\beta)\frac{R_1}{E}$$

Vol. r: $\frac{4\pi r^3}{3} = V$

$$V' = \frac{4\pi(r+u)^3}{3} = \frac{4\pi r^3}{3} + 4\pi r^2 u$$

$$V' - V = 4\pi r^2 u$$

$r_1 = r_0 + \alpha$

~~$r_1^3 - r_0$~~ $r_1^3 - r_0^3 = (r_0+\alpha)^3 - r_0^3 = 3r_0^2\alpha$

$$A = \frac{R_1(r_0+\alpha)^3 - R_0 r_0^3}{3r_0^2\alpha} = \frac{(R_1 - R_0)\,r_0^3 + 3R_1 r_0^2\alpha +}{3r_0^2\alpha}$$

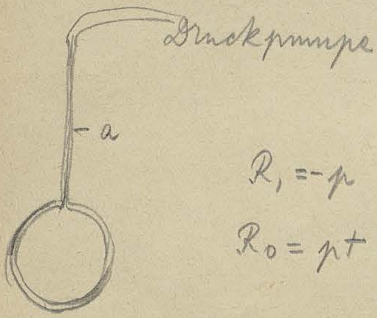
$$A = \frac{(R_1 - R_0)}{3\alpha}\,r_0 \quad + \ldots$$

$$B = \frac{r_0^6(R_0 - R_1)}{3r_0^2\alpha} = \frac{r_0^4(R_0 - R_1)}{3\alpha}$$

$$\frac{u_0}{r_0} = \frac{(1-2\beta)}{E}\frac{(R_1-R_0)}{3\alpha}r_0 - \frac{1}{2}\frac{(1+\beta)}{E}\,r_0\frac{(R_0-R_1)}{3\alpha}$$

$$= \frac{r_0}{3\alpha E}\left[R_1 - R_0\right]\left[1 - 2\beta + \tfrac{1}{2} + \tfrac{1}{2}\beta\right]$$

$$\frac{u_0}{r_0^2} = \frac{R_1 - R_0}{3\alpha E}\left[\frac{3}{2} - \frac{3}{2}\beta\right] = \frac{R_1 - R_0}{\alpha E}\,\frac{1-\beta}{2}$$



$p =$ atm [illegible]

$$R_1 = -p$$

$$R_0 = p + P$$

$$R_1 - R_0 = P$$

$$\frac{u_0}{r_0^2} = \frac{1-\beta}{2\alpha E} P \qquad \text{Vol. } \varsigma = 4\pi r_0^2 u_0 =$$

$$= \frac{4\pi(1-\beta)}{2\alpha E} P r_0^4$$

[illegible]

[illegible] $\frac{E}{1-\beta}$ [illegible] β [illegible]

$$A\left[\frac{e^{bl}+e^{-bl}}{2}+\cos bl\right] = -B\left[\frac{e^{bl}-e^{-bl}}{2}+\sin bl\right]$$

$$B\left[\frac{e^{bl}+e^{-bl}}{2}+\cos bl\right] = -A\left[\frac{e^{bl}-e^{-bl}}{2}-\sin bl\right]$$

$$AB\left[\frac{e^{bl}+e^{-bl}}{2}+\cos bl\right]^2 = +AB\left[\left(\frac{e^{bl}-e^{-bl}}{2}\right)^2-\sin^2 bl\right]$$

$$\left(\frac{e^{bl}+e^{-bl}}{2}\right)^2+\cos bl\,(e^{bl}+e^{-bl})+\cos^2 bl = \left(\frac{e^{bl}-e^{-bl}}{2}\right)^2-\sin^2 bl$$

$$\frac{1}{2}+\cos bl\,(e^{bl}+e^{-bl}) = -\frac{1}{2}-1$$

$$\underbrace{(e^{bl}+e^{-bl})}_{2+}\cos bl = -2$$

[illegible] $bl > \frac{\pi}{2}$

$\cos bl < -1$

$\pi > bl > \frac{\pi}{2}$ 1 [illegible]

$\frac{3\pi}{2} > bl > \pi$ 2 [illegible] $\frac{3\pi}{2}$

$3\pi > bl > \frac{5\pi}{2}$ [illegible] e^{bl} [illegible]

[illegible]

[illegible] $\frac{\pi}{2}$ [illegible]

[illegible] bl [illegible] $\frac{\pi}{2}$ [illegible] ∞ [illegible]

[illegible] 5 : 7 : 9 : 11

[illegible] 1 : 3 [illegible] $1+\alpha : 3-\beta$ [illegible] Hermon.

$bl = \delta$ = [illegible]

$b = \frac{\delta}{l}$ $\qquad \frac{\alpha}{a} = b^2$

$\alpha = a b^2$

$= \frac{2\pi}{\tau} = 2n\pi \qquad n = \frac{ab^2}{2\pi}$

$n = \frac{a\delta^2}{2\pi l^2}$ [illegible]

$a^2 = \frac{\mathcal{E} K}{\rho q}$

[illegible] = rechteckig

$V = b \qquad K = \frac{b h^3}{12}$

$n = h \qquad q = bh$

$a^2 = \frac{\mathcal{E} b h^3}{\rho\, bh\, 12} = \frac{\mathcal{E} h^2}{12 \rho} \qquad n = \frac{\delta^2 h}{2\pi l^2} \sqrt{\frac{\mathcal{E}}{12\rho}}$

[illegible]

[illegible] 200 [illegible]

[illegible] 8 [illegible]

28/6 Wheatstone's Kaleidophon

[illegible] Tremor [illegible]

[illegible]



[illegible] Octave

[illegible] $\sqrt{2}$: 1 [illegible] Octave [illegible]

[illegible]

[illegible] Octave; [illegible] [illegible]

[illegible St. illegible]; [illegible]

[illegible] transv [illegible] longit. [illegible]

[illegible]

[illegible]

[illegible]

[illegible] Reson. [illegible]

[illegible]

30/6 $z = U \sin \alpha t$

$$U = A\,\frac{e^{bx}+e^{-bx}}{2} + B\,\frac{e^{bx}-e^{-bx}}{2} + C\cos bx + D\sin bx$$

$$\frac{d^4U}{dx^4} = -b^4 U$$ [illegible] Coeff. [illegible]

[illegible]

$b_1 \quad b_2 \quad b_3$ — [illegible]

[illegible] U [illegible] A [illegible]

$$U = A\left(\frac{e^{bx}+e^{-bx}}{2} + \frac{B}{A}\,\frac{e^{bx}-e^{-bx}}{2} + \frac{C}{A}\right.$$

$$U_1 = A_1\left(\frac{e^{b_1x}+e^{-b_1x}}{2} + \right.$$

$$U_2 = A_2\left(\frac{e^{b_2x}+}{2}\right.$$